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ABSTRACT

Concentrating on strategies for processing information, this guide provides a collection of models and techniques appropriate for differentiating the content and instructional procedures in the classroom, and is designed for use with intermediate academically talented students. The guide is divided into four sections--Differentiated Questioning, Critical Thinking, Creative Thinking, and Problem Solving. The section on differentiated questioning compares several different taxonomies, discusses Bloom's Taxonomy in detail, and suggests procedures for developing questions with students, including a divergent question model. In the critical thinking section, sample lessons are provided for semantics, logic, and authenticity, and includes resource/activity sheets for each lesson. The section on creative thinking covers the topics of fluency, flexibility, originality, elaboration, and evaluation strategies. Finally, the problem solving section discusses various problem solving strategies and models, such as inductive and deductive reasoning, synectics, and the Whole Mind Approach. All sections provide teacher self-evaluation forms and bibliographies for related readings. (MM)

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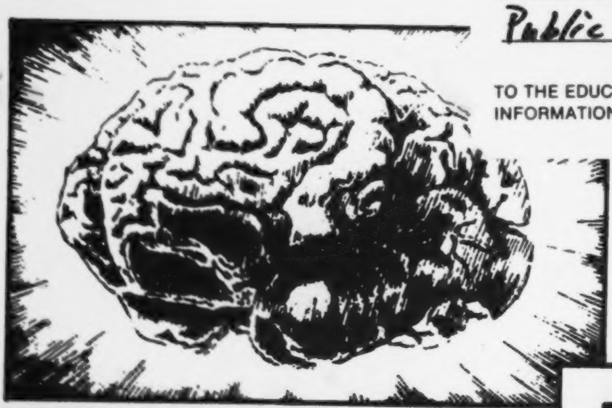

QUESTIONING

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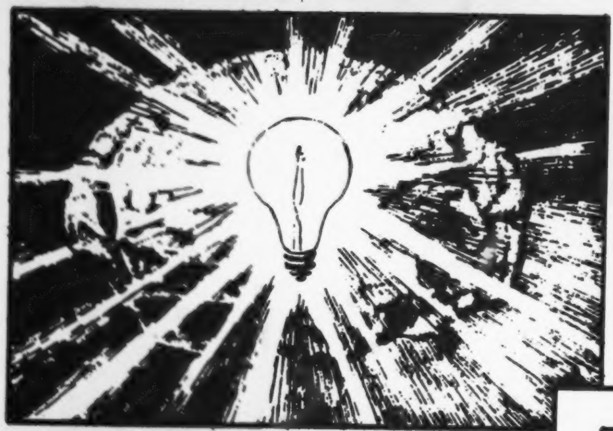

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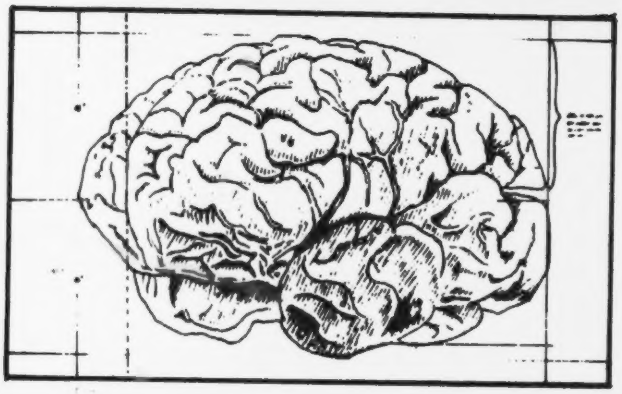
CRITICAL THINKING



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STRATEGIES for DIFFERENTIATING CURRICULA

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BALTIMORE COUNTY PUBLIC SCHOOLS

STRATEGIES FOR DIFFERENTIATING CURRICULA

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FOREWORD

The Baltimore County Public Schools are dedicated to the pursuit of excellence in the vital mission of educating students to become creative, productive, and contributing members of society. The Board of Education of Baltimore County has long encouraged and supported the development of curriculum by teachers and other administrative and supervisory personnel. Teachers occupy the key role in delivering instructional services to students, and their involvement in the development of materials is indispensable to the achievement of a sound educational system.

The scope and sequence of the resource materials prepared by teachers, supervisors, and administrators focus on the primary concern of all educators: what students learn, how they learn, and the degree of their achievements. As a result, Baltimore County students have the advantages of outstanding curricula reflecting the most recent methods and materials, designed specifically to meet their particular needs.

The tradition of teacher involvement in curriculum workshops in Baltimore County has contributed significantly to the quality of the curriculum guides, handbooks, and manuals. We are pleased that many of the curricular materials developed by our staff have influenced program designs in other school systems throughout the nation.

Strategies for Differentiating Curricula and other 1985 curriculum publications help meet our challenge of providing students with the knowledge and skills required for modern living.

This guide explains strategies for differentiating curriculum for all students. The examples and implementation ideas were developed to show differentiation for academically talented students at the intermediate level.

The guidelines and suggestions in this bulletin are presented with the expectation that they will make valuable contributions to the quality of our educational program and will stimulate the minds and imaginations of our students.

Robert Y. Dubel
Superintendent

July 1985

ACKNOWLEDGEMENTS

Sincere appreciation is extended to the many county professionals who have made a dedicated contribution to the completion of this project, and who have demonstrated a truth voiced by Arthur Koestler:

> *The creative act consists in*
> *combining previously unrelated*
> *structures in such a way that*
> *you get more out of the emergent*
> *whole than you have put in.*

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CONTENTS

Page

RATIONALE 1

USE OF THE GUIDE 3

DIFFERENTIATED QUESTIONING: Overview 5

  Teacher Self-Evaluation. 9

  A Comparison of Taxonomies 11

  Key Words for Bloom's Taxonomy of Cognitive Processes. . . . 12

  Application of Bloom's Taxonomy: Single Concept. 13

  Sample Questions Using Bloom: Cinderella 14

  Applications for Each of Bloom's Levels. 15

  Developing Critical Level Questions with Students. 21

  Developing Creative Level Questions with Students. 25

  Demonstration of Literal and Critical Questioning as the Foundation for Creative Production 27

  Divergent Questioning Model. 29

  Application of the Divergent Questioning Model: Single Concept 30

  Sample of Divergent Questioning: Cinderella. 31

  Application of the Divergent Model: Lesson 32

  Tri-Level Review of Questioning. 33

  Reminders for Effective Questioning. 34

  Bibliography 35

CRITICAL THINKING: Overview 37

  Teacher Self-Evaluation. 41

  Semantics. 43

    Sample I: Vague and Precise Language 44

    Sample II: Analogies 49

7

Logic 55
  Sample I: Perceiving Attributes and Associates 56
  Sample II: Truth-Value Statements 65
  Sample III: Strength of Arguments 75
  Sample IV: Matrix Logic 81
Authenticity 89
  Sample: Fact, Opinion, Values 90
Bibliography 99
CREATIVE THINKING: Overview 103
Teacher Self-Evaluation 107
Creativity: A Disciplined Process 109
A Model for Encouraging Creative Learning 110
Creative Reading Checklist 113
Fluency 115
  Brainstorming 115
  Suggested Brainstorming Procedures 116
Flexibility 118
  Attribute Listing 118
  Attribute Listing Procedure 118
  Variations of Attribute Listing 119
    Concept Formation 120
    Concept Attainment 120
    Morphological Forced Connections 121

Originality 123
Analogy in Critical Thinking 124
Analogy in Creative Thinking 125
Synectics 125
Application of Analogous Relationships 126
Elaboration 129
SCAMPER 129
SCAMPER Questions 130
Application of SCAMPER 131
Content Area Applications 133
Guidelines for Visual Brainstorming 134
Evaluation 137
Strategies for Evaluation 138
Evaluative Thoughts Worth Thinking About 141
Bibliography 143
PROBLEM SOLVING: Overview 147
Problem Solving Hierarchy 150
Teacher Self-Evaluation 153
Problem Solving Strategies 155
Basic Strategies 156
Use of Questions in Metacognition 157
Problem Solving Models 158
Models for the Scientific Method 159
Comparison of Induction and Deduction Chart 160
Content Area Applications of the Scientific Method 161
Introducing a Skill: An Inductive Strategy 162
Introducing a Skill: A Deductive Strategy 163

Creative Problem Solving (CPS) 164

Application of the CPS Model 167

Example of a Simplified CPS Model 171

Suggestions for Utilizing CPS. 172

Other Problem Solving Models 178

Obstacles to Effective Problem Solving 182

Suggestions for Overcoming Obstacles 183

Suggestions for Creating a Problem Solving Environment 184

Bibliography 185

APPENDIX: Resource Sheet Listing 189

RATIONALE

Strategies for Differentiating Curricula provides a collection of models and techniques appropriate for differentiating the content and instructional procedures in the classroom. Although all students can benefit to some degree from these modifications, academically talented students require differentiated educational programs and services beyond those normally provided. Although they are unique, they share the need of all students to develop in a learning environment commensurate with their ability and potential. The characteristics which distinguish academically talented students from their age peers include a high degree of independence, curiosity, perception, retention, task-commitment, persistence, reasoning, and the higher levels of cognition, such as abstract, critical, productive, and creative thinking. Such students also differ characteristically and developmentally from one another. As a result, educational programs for these students must be qualitatively different and provide opportunities for extending and expanding the regular curriculum. Planned learning experiences should be of greater breadth, depth, and intensity; they should enhance the development of affective, as well as cognitive,skills.

Current research confirms that students should be formally taught to analyze the cognitive processes. Metacognition, or thinking about thinking, helps students to understand their abilities and talents better so that they can become more efficient learners. It is evident that recognition and application of processing strategies contributes to the ability of students to set their own goals for independent learning.

The role of the teacher is most important for the effective implementation of these strategies; a flexible teaching attitude, the knowledge of the learning styles and needs of the students, and a creative learning enviroment are essential. Moreover, the students need to know the specific objectives and purpose for each learning situation. They need to know that such strategies are tools for learning which can set them free intellectually; the teacher needs to accept the role of facilitator in the process. For as Gibran says of the teacher:

> If he is indeed wise
> he does not bid you enter the house
> of his wisdom,
> but rather leads you
> to the threshold of your own mind.

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USE OF THE GUIDE

Strategies for Differentiating Curricula concentrates on strategies for processing information. Consideration has been given to the differentiated use of content, to the development of products, and to the learner as a person.

The guide is divided into four sections:

Questioning

Critical Thinking

Creative Thinking

Problem Solving.

It is recognized that these aspects of cognition are closely interwoven. The strategies in each section are multi-disciplinary and should be used to differentiate curricula as a need arises.

Although these strategies should be used with all students, examples and model lessons in this guide have been designed for use with intermediate academically talented students.

DIFFERENTIATED QUESTIONING: OVERVIEW

- Differentiated Questioning Explained
- Teacher Self-Evaluation
- Comparison of Taxonomies Chart
- Bloom's Taxonomy
  - Key Words
  - Development of Single Concept: "Coniferous"
  - Questions Applied to Story: "Cinderella"
  - Applications at Each Level
    - . Level Defined
    - . Thinking Process
    - . Examples
      - - Math
      - - Social Studies and Science
      - - Language Arts
    - . Question Starters
    - . Explanatory Comments
- Developing Questions with Students: Suggested Procedures
  - Critical | Application / Analysis
  - Creative | Synthesis / Evaluation
  - Literal and Critical Levels as the Foundation for Creative Production
- Divergent Questioning Model
  - Definitions and Question Starters
  - Development of a Single Concept: "Coniferous"
  - Questions Applied to Story: "Cinderella"
  - Developing the Divergent Model with Students
- Tri-Level Review
  - Reinforce, Review, or Assess
- Reminders
- Bibliography for Questioning Strategies

DIFFERENTIATED QUESTIONING

> *It is in fact nothing short of a miracle that the modern methods of instruction have not entirely strangled the holy curiosity of inquiry; for this delicate little plant, aside from stimulation, stands mainly in need of freedom; without this it goes to wrack and ruin without fail.*
>
> *- Albert Einstein*

Nurturing the "curiosity of inquiry" is the foundation of all good teaching but presents a special challenge to the teachers of the academically talented students. Differentiated questioning is a concentration on the upper levels of questioning taxonomies with an emphasis on the freedom of shared inquiry. Academically talented students require the extra "stimulation" of differentiated questioning; it aids the improvement of thinking skills and supplies a strategy whereby such students can become independent learners in the world at large.

Differentiated questioning techniques should be used in all subject areas to facilitate meeting a variety of objectives in Baltimore County's scope and sequence guides.

The teacher needs to model effective questioning by maintaining a non-judgmental atmosphere, by encouraging diversity of thinking, and by participating in the shared inquiry process as a learner. Students should be guided to understand that there are a variety of questioning models and that such models provide a structure for disciplined, as well as creative, thinking. Questioning should be emphasized as an ongoing process which frequently requires the return to lower taxonomic levels in order to be successful at the upper levels.

There are many sources available for sound questioning; the purpose of this guide is to demonstrate ways to differentiate and to provide models and suggestions for use with academically talented students in the classroom.

> *There are no foolish questions, and no man becomes a fool until he stops asking questions.*
> *- Steinmetz*

Perhaps there are no foolish questions, but some questions are less foolish than others. More positively stated, some questions are clearly better than others. The use of hierarchies, such as Bloom's Taxonomy of Cognitive Objectives, illustrates that inquiry can be interpreted and generated at various degrees of intellectual complexity.

The ability to recognize, employ, and respond to questions at various levels can be learned. Teachers can structure questions to elicit higher levels of response from students. Students can learn to formulate questions that will challenge their thinking and achievement. Models have been provided to demonstrate how students can be directed to improve thinking by answering and creating questions at higher levels.

Models and examples also present ideas for applying levels of questions in various content areas. For example, questions about a single science term such as coniferous can lead to ideas at higher levels. Levels of questions have also been applied to a familiar story, "Cinderella," to demonstrate ways effective questioning can stimulate discussions. The Divergent Questioning Model provides a variety of strategies for developing questions and responses at the synthesis level which has wide application to projects and independent study in all disciplines. (Additional applications for synthesis strategies are presented in the "Creative Thinking" section.)

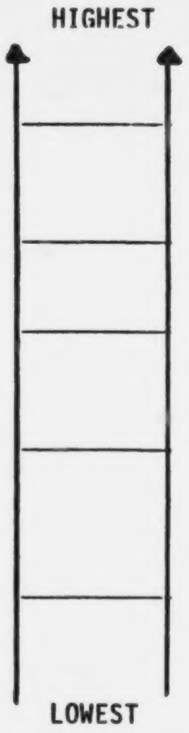
Each of Bloom's levels may be directly taught; however, the tri-level taxonomy (literal, critical, and creative), identified by the State of Maryland, delineates characteristics which more clearly distinguish one level of thinking from another. Suggested procedures demonstrate ways students may develop questions at critical and creative levels. The importance of literal and critical levels as the foundation for creative production is demonstrated using the topic of the moon.

Although the three levels have been described separately, there is, nevertheless, a dynamic interaction of the processes, especially at the highest levels. Convergent and divergent thinking alternate throughout critical and creative activities, much as a Möbius strip. Evaluation, in its purest form, usually appears at the top of taxonomies but occurs, in reality, in a spiraling fashion throughout the levels of cognition. At times, students need to perceive levels as unique categories; however, they should also be made aware of the relationships between the levels.

TEACHER SELF-EVALUATION FOR DIFFERENTIATED QUESTIONING STRATEGIES

	ALWAYS	USUALLY	SOMETIMES	NEVER
1. I use a variety of questioning strategies.				
2. I teach my students to recognize levels of questioning.				
3. I provide opportunities for my students to produce questions at the higher levels.				
4. I teach my students to value the inquiry process.				
5. I provide opportunities for my students to critique questions from a variety of sources.				
6. I teach my students ways of responding to ambiguous questions.				
7. I teach my students methods for applying levels of questions appropriate to a given situation.				
8. I encourage students to respond freely to questions without imposing my judgment.				
9. I provide my students with a balance of convergent and divergent questions.				
10. I create a discussion setting that facilitates student-student interaction.				
11. I direct students' questions to other students for answers and/or comment.				
12. I encourage my students to see relationships among disciplines.				
13. I model the kinds of questions I want students to ask.				
14. I teach my students to appreciate questioning as a process for improving thinking skills.				
15. I ask questions that stimulate further questions.				

A COMPARISON OF TAXONOMIES



BLOOM	SANDERS	JUNIOR GREAT BOOKS	MARYLAND STATE
Evaluation	Evaluation	Evaluative	Creative
Synthesis	Synthesis		
Analysis	Analysis	Interpretive	Critical
Application	Application		
Comprehension	Interpretation Translation	Factual	Literal
Knowledge	Memory		

The Comparison of Taxonomies demonstrates the correlation of levels of thinking for various questioning models. Students should recognize that a hierarchy of questioning provides a structure for improving the thinking process. Whichever taxonomy is utilized, students should be taught operational definitions for the terms so that they can apply the concepts effectively.

KEY WORDS FOR BLOOM'S TAXONOMY OF COGNITIVE PROCESSES

6. **EVALUATION** - Judging material, ideas, and problems based on established criteria.

debate defend evaluate
judge recommend select

5. **SYNTHESIS** - Producing a solution using original, creative thinking.

compose create formulate
design imagine predict

4. **ANALYSIS** - Breaking down the given material into its constituent parts and seeing relationships.

analyze categorize classify
distinguish separate survey

3. **APPLICATION** - Using what has been learned to solve a new problem.

apply choose compute
construct demonstrate report

2. **COMPREHENSION** - Showing that the meaning of the material has been understood.

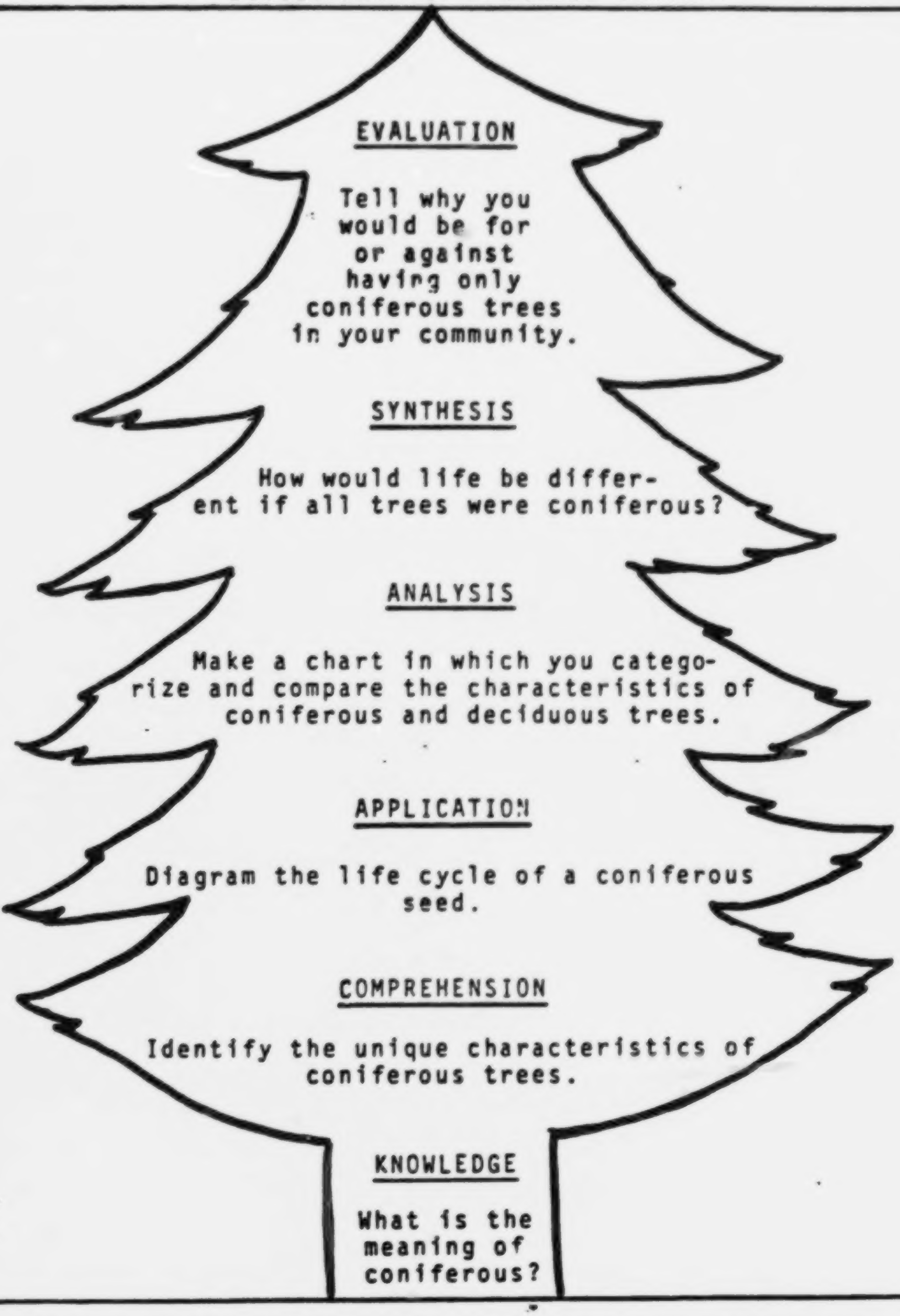
explain illustrate interpret
match rephrase tell how

1. **KNOWLEDGE** - Remembering what has been learned through recall or recognition.

define identify list
locate name state

Key words can be very effective for presenting questions at various levels. However, the nature of the information available to the student and the standards established for the end product will determine whether or not the response is completed at the desired level. The combination of key words and question starters helps to formulate instructional objectives at the desired taxonomic level.

APPLICATION OF BLOOM'S TAXONOMY FOR THE DEVELOPMENT OF A SINGLE CONCEPT



EVALUATION

Tell why you would be for or against having only coniferous trees in your community.

SYNTHESIS

How would life be different if all trees were coniferous?

ANALYSIS

Make a chart in which you categorize and compare the characteristics of coniferous and deciduous trees.

APPLICATION

Diagram the life cycle of a coniferous seed.

COMPREHENSION

Identify the unique characteristics of coniferous trees.

KNOWLEDGE

What is the meaning of coniferous?

The taxonomy of thinking defined by Bloom provides guidelines for developing appropriate questions. Use of key words (p. 12) facilitates question building. In this application of the levels to a single concept, the term coniferous has evolved from a basic knowledge level to the higher order skill of evaluation. This array demonstrates the importance for a solid foundation of knowledge and comprehension.

SAMPLE QUESTIONS USING BLOOM

CINDERELLA

EVALUATION

Prove that the stepmother was a good parent to Cinderella. Justify your answer with examples from the story.

Do you think Cinderella should have run away at the stroke of midnight? Why?

Judge the Prince's wisdom in his selection of Cinderella as his bride.

SYNTHESIS

If you had been the Prince, what would you have done to find Cinderella?

What would have happened to Cinderella if the Prince had not found her?

Suppose you could give Cinderella a modern invention. What would you give her, and how would that change the story?

ANALYSIS

Why did the Prince go to so much trouble to find Cinderella?

Why did Cinderella continue to live with her stepmother and stepsisters?

Why does the author make Cinderella shy and obedient?

APPLICATION

Write a simile and metaphor to describe one of the characters.

Select an example from the story to show that the two stepsisters were jealous of Cinderella.

Show your understanding of the story by constructing a time line of the main events.

COMPREHENSION

Summarize the story of Cinderella.

What is the main idea?

Outline the main events.

KNOWLEDGE

How many stepsisters did Cinderella have?

What was the occasion for the ball?

What did Cinderella lose at the stroke of midnight?

APPLICATION FOR LEVELS OF QUESTIONING: KNOWLEDGE

Level 1 - KNOWLEDGE: To obtain answers to questions directly from the information presented.

THINKING PROCESS: Recalling or recognizing facts, concepts, and generalizations previously encountered.

EXAMPLES

MATH	SOCIAL STUDIES AND SCIENCE	LANGUAGE ARTS
. List the facts in the fives' times table.	. Describe the purpose of taking accurate measurements	. Name the main character of the story.
. Define a polygon.	. Which member of the Calvert family became the first governor of Maryland?	. List the reasons given for Sam's decision to leave home in My Side of the Mountain.

QUESTION STARTERS

What is ______________________________?

How is ______________________________?

Where is ______________________________?

When did ______________________ happen?

How did ______________________ happen?

Who ______________________________?

Define ______________________________.

Explain ______________________________?

Knowledge is a step at a literal level which requires the student to express facts or ideas as stated in an original source. Students must have a broad foundation about a topic at this step before they can develop understandings at higher levels of cognition. A knowledge question is determined by the nature of the content. For example, the sample question from "Cinderella" for Knowledge (p. 14), "What was the occasion for the ball?" could be a question for a higher level if the expected response is not explicitly expressed in the text.

APPLICATION FOR LEVELS OF QUESTIONING: COMPREHENSION

Level 2 - COMPREHENSION: To organize and select facts and ideas in material by giving descriptions, stating main ideas, or comparing.

THINKING PROCESS: Discovering relationships between two or more concepts, generalizations, or facts

Changing information from one form to another.

EXAMPLES

MATH	SOCIAL STUDIES AND SCIENCE	LANGUAGE ARTS
. Explain the Commutative Property of Addition in your own words.	. In your own words explain the difference between indentured servants and slaves after reading pages 28 and 29, in Let's Learn About Maryland.	. Find evidence in your readings that Paul Bunyan could perform unusual feats of strength.

QUESTION STARTERS

Describe ______________________.

What is the main idea of ________________?

Interpret or put in your own words __________.

Compare__________ alike/different __________.

How are _______________________?

Discuss _______________________.

Clarify _______________________.

What can you say about ________________?

Which is the best answer? ______________?

Comprehension is a step at a literal level which requires the student to reorganize and restate facts and ideas as main ideas, comparisons, descriptions, and summaries. The student must be able to recognize the facts relevant to the question asked. In basic comprehension questions, all information necessary for the response is present in the content. Students are responding at a comprehension step when they make a summary or comparison based solely on the information given.

APPLICATION FOR LEVELS OF QUESTIONING: APPLICATION

Level 3 - APPLICATION: To solve problems using acquired knowledge or application of facts, techniques, or rules.

THINKING PROCESS: Recognizing ways to apply what has been learned to a new situation.

EXAMPLES

MATH	SOCIAL STUDIES AND SCIENCE	LANGUAGE ARTS
. Solve problems 1-10.	. Develop a Magna Carta for our classroom.	. How can you use the ideas from this magazine to help you save energy at home?
. Measure the classroom and make a scale drawing of 1/2 inch to a foot.	. Construct another experiment to show the reaction of a paramecium when an obstacle is placed in its path.	. Write the directions for how to make tacos, based on your understanding of the story.

QUESTION STARTERS

Demonstrate a use for ____________ by ____________.

Select examples of ________________________.

Solve ________________ using what you have learned.

Organize ________________ to show ____________.

Construct a model of ________________________.

Apply ________________ to ________________.

Application is a step at the critical level which requires the student to utilize information previously learned in a new context. Students must be able to recognize, recall, and comprehend ideas and processes and apply them with a minimum of direction. A response at the application level occurs when the student has mastered the skills necessary for accomplishing the task. For instance, in the example for the application question ("Cinderella," p. 14), the student must comprehend the story and be able to write similes and metaphors.

APPLICATION FOR LEVELS OF QUESTIONING: ANALYSIS

Level 4 - ANALYSIS: To analyze constituent elements by identifying motives or causes, making inferences, and finding evidence to support generalizations.

THINKING PROCESS: Separating material into basic parts and explaining how they are related.

EXAMPLES

MATH	SOCIAL STUDIES AND SCIENCE	LANGUAGE ARTS
. Explain how the Pythagorean Theorem is helpful in the construction of a pyramid.	. How has the invention of the plow changed farming in Maryland?	. List and explain how the following statements help to make the argument valid.
. Provide the next number in the following set: (1,4,9,16,....).	. Explain the strengths and weaknesses of an external skeleton as opposed to an internal skeleton.	. What evidence can you find to prove that the ad-maker is appealing to a particular audience?

QUESTION STARTERS

Classify/categorize ____________________.

How is ____________ related to __________?

List reasons for ____________________.

Delineate ____________________.

Infer ____________________.

What evidence can you find to ______________?

What does __________ tell us about __________?

Analysis is a step at the critical level which requires the student to use the parts and processes of reasoning in order to determine the relationships of elements and principles. Students must be able to recognize and apply reasoning and inference skills such as drawing conclusions, challenging assumptions, and making generalizations. An analysis response occurs when the student is able to construct an answer that is neither right nor wrong, but is the best answer derived from available information.

APPLICATION FOR LEVELS OF QUESTIONING: SYNTHESIS

Level 5 - SYNTHESIS: To combine ideas in unique ways such as solving problems, making predictions, or producing original communications.

THINKING PROCESS: Putting ideas together in a new and original form; to think creatively and divergently.

EXAMPLES

MATH	SOCIAL STUDIES AND SCIENCE	LANGUAGE ARTS
. Brainstorm all the ways you can express eight divided in half.	. Explain how our clothing styles might be affected if we had an external skeleton. Draw pictures to illustrate the new styles for men and women.	. Imagine you are an endangered animal and develop an ad campaign to preserve your species.
. Design a tessellation using at least three polygons.	. Explain how your life would be different if you lived in a domed city.	. Create a society like the one in Twenty-One Balloons. How would you restructure time and why?

QUESTION STARTERS

Modify ______________________________.

What if ______________________________?

What is another way ____________________?

Design a new use for ___________________.

Elaborate ____________________________.

Invent _______________________________.

Synthesis is the step at the creative level which requires the student to combine skills and concepts and to generate unique, but meaningful, outcomes. Students must have a firm foundation of a topic at the literal and critical levels before they can make a synthesis response. An answer or product may be considered creative if it represents a new insight for the student. For example, a diorama may demonstrate production at the comprehension or application level if it merely reflects a literal interpretation of the context. It may become a creative outcome, however, if the student has transformed materials or concepts into a unique integration and manipulation of relationships.

The Divergent Questioning Model (p.29) provides additional strategies for developing synthesis activities.

APPLICATION FOR LEVELS OF QUESTIONING: EVALUATION

Level 6 - EVALUATION: To judge the value and validity of ideas or quality of work.

THINKING PROCESS: Deciding to accept a subjective judgment on the basis of objective criteria.

EXAMPLES

MATH	SOCIAL STUDIES AND SCIENCE	LANGUAGE ARTS
. Select the best geometric construction to support the maximum amount of weight.	. Decide whether you prefer to live in an urban or rural setting. Support your decision.	. Do you agree with the editorial? Defend your answer.
. Debate whether the metric system or the English Standard of measurement is better for our economy.	. Evaluate the use of energy in your home and decide how it could be used more efficiently.	. Would you recommend this book to a friend? Why or why not?

QUESTION STARTERS

Why do you think ______________________________?

Do you agree ______________________________?

What is your opinion of ______________________________?

Prove/disprove that ____________ is better than ________.

Rank order ______________________________.

Assess the value or importance of ____________________.

Would it be better if ______________________________?

Evaluation is a step at the creative level which requires the student to determine the criteria necessary for making a decision or a judgment about the quality of a situation or product. Students must involve the combination of all steps at the literal, critical, and creative levels in order to make evaluative responses. However, they also need to recognize that the subjective nature of values influences judgments. Therefore, evaluative responses are neither right nor wrong; they can be judged in terms of the criteria against which they are measured. Moreover, some evaluation occurs at each level, since, even in the choice of words to answer knowledge level questions, one must decide which words best express the answer. Additional examples of evaluation are provided in the "Creative Thinking" section (pp. 137-140).

DEVELOPING CRITICAL LEVEL QUESTIONS WITH STUDENTS

APPLICATION
ANALYSIS

OBJECTIVE: The student will recognize and construct critical level questions.

PROCEDURE:

1. Have the students read Resource Sheet, p. 23, "As Busy As a Bee?" the "Ecosystems" Unit, Level Five, Elementary Science Program for Baltimore County.

2. Review literal questions by presenting items such as:
   - How much can an earthworm eat in 24 hours?
   - Describe three ways earthworms help people.
   - How are the earthworms' tunnels useful?

3. Have the students discuss the characteristics that define literal level questions.

4. Present critical level items without labels, such as:
   - Construct a bar graph comparing the mineral content of the earth's soil and the castings of the earthworms.
   - Demonstrate how the earthworm is an integral part of the soil and water ecosystems.
   - How many earthworms are necessary to produce topsoil for a truck farm of 7-1/2 acres?

5. Have the students compare the two sets of questions and list the characteristics of the second set.

6. Explain that the kinds of questions in the second set are called Critical Level Questions. With the students, develop an operational definition for Critical Level Questions. Refer to "Key Words for Bloom's Taxonomy of Cognitive Processes," p. 12.

7. Have the students read a short selection from a common source, such as a social studies text or a basal reader, to construct at least two different critical level questions.

8. Have the students write their best questions on the board and analyze them with reference to the operational definition they developed.

9. Provide opportunities for students to discuss and evaluate their questions and the quality of their responses.

EXTENSION ACTIVITIES:

1. Have the students analyze the kinds of questions used in an interview on television.

2. Have the students analyze the comments and questions used in a sports commentary.

3. Role play an interview situation in which the questioner asks only literal questions. Have the students develop a list of critical questions that would make the interview more interesting. Re-enact the role play using the new questions.

    . Have a student research a historical figure and assume the role of the interviewee.

    . Have a student take a stand on a debatable issue and assume the role of the interviewee or the interviewer. Refer to Critical Thinking, Book I by Anita Harnadek, pp. 167-169, for debate procedures.

4. Have the students analyze a book review from a newspaper or magazine. Identify and categorize the questions probably used by the reviewer to evaluate the book.

5. Have the students analyze letters to the editor about a current issue and make a list of critical questions which are raised in their minds by the controversy expressed.

6. Have the students read a selection, such as Mrs. Frisby and the Rats of NIMH or The Pushcart War, and determine the kinds of questions the author wishes the reader to consider.

7. Have the students make a collection of the kinds of questions used to help solve math problems and list the critical and literal levels of information needed for solutions.

8. Select a matrix logic problem. Have the students record and categorize the types of questions they need to ask in order to solve the problem.

9. Have the students analyze a questionnaire on a topic, such as nuclear energy or conservation of energy, to determine the degree of bias implied in the questions.

10. Have the students develop a questionnaire about a controversial topic.

11. Have the students develop a set of questions that could be used to evaluate projects of fellow classmates.

As Busy As A Bee? Try The Earthworm

Washington (Special)—The humble earthworm makes the busy bee look like a loafer.

The remarkable worm works so hard and so well that it could justly claim to be man's best friend.

No less a scientist than Charles Darwin wrote: "It may be doubted if there are any other animals which have played such an important part in the history of the world as these lowly organized creatures."

As a soil creator, conditioner, and preserver, the earthworm has no rivals.

Eats Its Weight

Tirelessly boring through the ground, an earthworm eats its weight in organic matter and mineral soil every 24 hours. It takes in leaves, grass, stems, dead insects and animals, larvae, and the like along with subsoil.

All of this material passes through the worm's formidable digestive system, which includes a muscular gizzard where soil is thoroughly ground. The residue is deposited in the familiar mounds called "castings."

These castings actually are enormously rich topsoil. Compared to the surroundinv earth, castings contain five tives as much nitrogen, seven times as much phosphorus, eleven times as much potash, and three times as much magnesium—in a form that plants can readily use.

Produce Topsoil

More than 1,750,000 earthworms may churn through one acre of rich farmland, producing as much as 40 tons of topsoil every year. Their tunnels aid root growth, allow air to penetrate underground, and improve drainage, thus preventing erosion.

Besides farmers and fishermen—who have found angleworms good bait for centuries—the earthworm aids archeologists. Their ceaseless activities over the centuries gradually have helped to cover and preserve ancient cities.

A few years ago, worms even pointed the way to a lost city. An archeologist searching for an ancient Roman city outside Vienna saw bits of brightly colored soil among worm castings. Analysis showed the bits to be from Roman frescoes. The site was excavated, and the remains of Roman buildings emerged from a thick layer of humus. •

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DEVELOPING CREATIVE LEVEL QUESTIONS WITH STUDENTS

SYNTHESIS

EVALUATION

OBJECTIVE: The student will recognize and construct creative level questions.

PROCEDURES:

1. Have the students reread "Busy As A Bee" (p. 23).
2. Review literal and critical levels of questions with students (p. 21).
3. Have the students discuss the characteristics that define literal and critical questions.
4. Present creative level items without labels, such as:
   - Prepare a list of similes or metaphors that could be used to describe the earthworm and use them in a poem.
   - Develop a campaign to persuade people to adopt earthworms as pets.
   - Debate Charles Darwin's statement about the earthworm which is quoted in the article.
5. Have the students compare the three types of levels and describe how the final set is different.
6. Explain that the types of questions in the final set are called Creative Level Questions. With the students, develop an operational definition for Creative Level Questions. The teacher may wish to refer to "Key Words for Bloom's Taxonomy of Cognitive Processes," p. 12.
7. Have the students read a short selection from a common source, such as a social studies text or a basal reader, and construct at least two different creative level questions.
8. Have the students write their best creative questions on the board and analyze them with reference to the operational definition they have developed.
9. Provide opportunities for the students to discuss and evaluate their questions and the quality of their responses.

EXTENSION ACTIVITIES:

1. Have the students identify the creative, critical, and/or literal levels of questioning used in basal reader selections.

2. Record a small group discussion of a reading selection or a current events issue. Have the students analyze the levels of questions and the quality of the responses expressed. Develop criteria for improving the questions and the responses.

3. Have the students make a collection of cartoons in which questions play an integral part. Have them categorize the kinds of questions asked as creative, critical, and/or literal.

4. Have the students label the levels of questioning involved in a list of project suggestions or enrichment ideas. Students should be prepared to explain the criteria used for making their decisions.

5. Have the students brainstorm a list of projects that could be developed for a given topic. Have them classify the project suggestions as creative, critical, and/or literal.

6. Have the students brainstorm all the questions that are raised after reading a selection, such as The Pushcart War, and categorize them.

7. Have the students design a diagram, tree, or flow chart for the sequence of questions they needed to ask as they developed an independent project.

> *To raise new questions, new possibilities, to regard old problems from a new angle requires creative imagination and marks real advances in science.*
>
> *- Albert Einstein*

DEMONSTRATION OF LITERAL AND CRITICAL QUESTIONING AS THE FOUNDATION FOR CREATIVE PRODUCTION

Academically talented students should be provided with many opportunities to perform at the highest levels of thinking taxonomies. However, even talented students need to build a foundation of knowledge and practice before they can effectively develop original ideas. The following example demonstrates how a teacher's questioning hierarchy can be used to provide the core of information necessary for creative production. Whenever possible, students should be provided with opportunities to evaluate their responses at each level in order to improve their response level, as well as the ability to ask effective questions.

TOPIC: Moon

LITERAL LEVEL | Knowledge
Comprehension

- Where is the moon located?
- Of what is the moon made?
- What is the size of the moon?
- Does the moon have an atmosphere? If so, what?
- How old is the moon?
- How was the moon formed?
- How long does it take the moon to orbit the earth?
- What is the temperature on the moon?
- Why do earthlings see only one face of the moon?
- What effect does the moon have on the earth?
- In what direction does the moon travel in its orbit around the earth?
- Does the moon turn on its axis? How often? In what direction?

CRITICAL LEVEL | Analysis
Application

- Observe the moon for a month. For each phase of the moon seen from your location on earth, draw the moon's location relative to the sun and earth.

- Develop a demonstration of a lunar eclipse and/or a solar eclipse.

- Given the information below, complete a moon chart showing the phase, date, rising and setting times of the moon at your location.

PHASE	RISE	SET	
Last Quarter	11:39	10:11 A.M.	3/23

- How many orbits of the earth does the moon make in one year? Show all work.

CREATIVE LEVEL | Synthesis
Evaluation

- Describe what would happen if the moon were half its size; twice its size.

- Decide whether you would prefer to live with or without the moon. Support your decision.

- How is the moon like the earth?

- Plan a base on the moon for human life.

- What would happen if the moon had an orbit in the plane of the earth's poles?

DIVERGENT QUESTIONING MODEL

QUANTITY QUESTIONS - By using this type of question, you will encourage the students to be fluent in their thinking. We also call this process brainstorming.

- List all the ______________________.
- What are all the possible solutions you can think of ______________?

SUPPOSITION QUESTIONS - By using this type of question, you ask the students to imagine that something is true and to consider the consequences. This activity may also require the reorganization of information.

- What would happen if ___________________ were true?
- Suppose ____________ happened, what would be the consequences?

VIEWPOINT QUESTIONS - By using this type of question, the students must be flexible in their thinking and try to see things from a different point of view.

- How would this look to a ______________________?
- How would ____________________________ view this?

INVOLVEMENT QUESTIONS - By using this type of question, you will encourage the students to use associative thinking. They will draw analogies between their own feelings and another object of association.

- How would ____________ feel if it were human and had feelings?
- If you were ____________ what would you (do, think, feel)?

FORCED ASSOCIATIONS - By using this type of question, you are asking your students to use associative thinking. They will concentrate on making comparisons between different things.

- How is a _____________ like a ____________?
- Get ideas from _____________ to improve _____________.

The Divergent Questioning Model is an effective tool for developing questions at Bloom's synthesis level.

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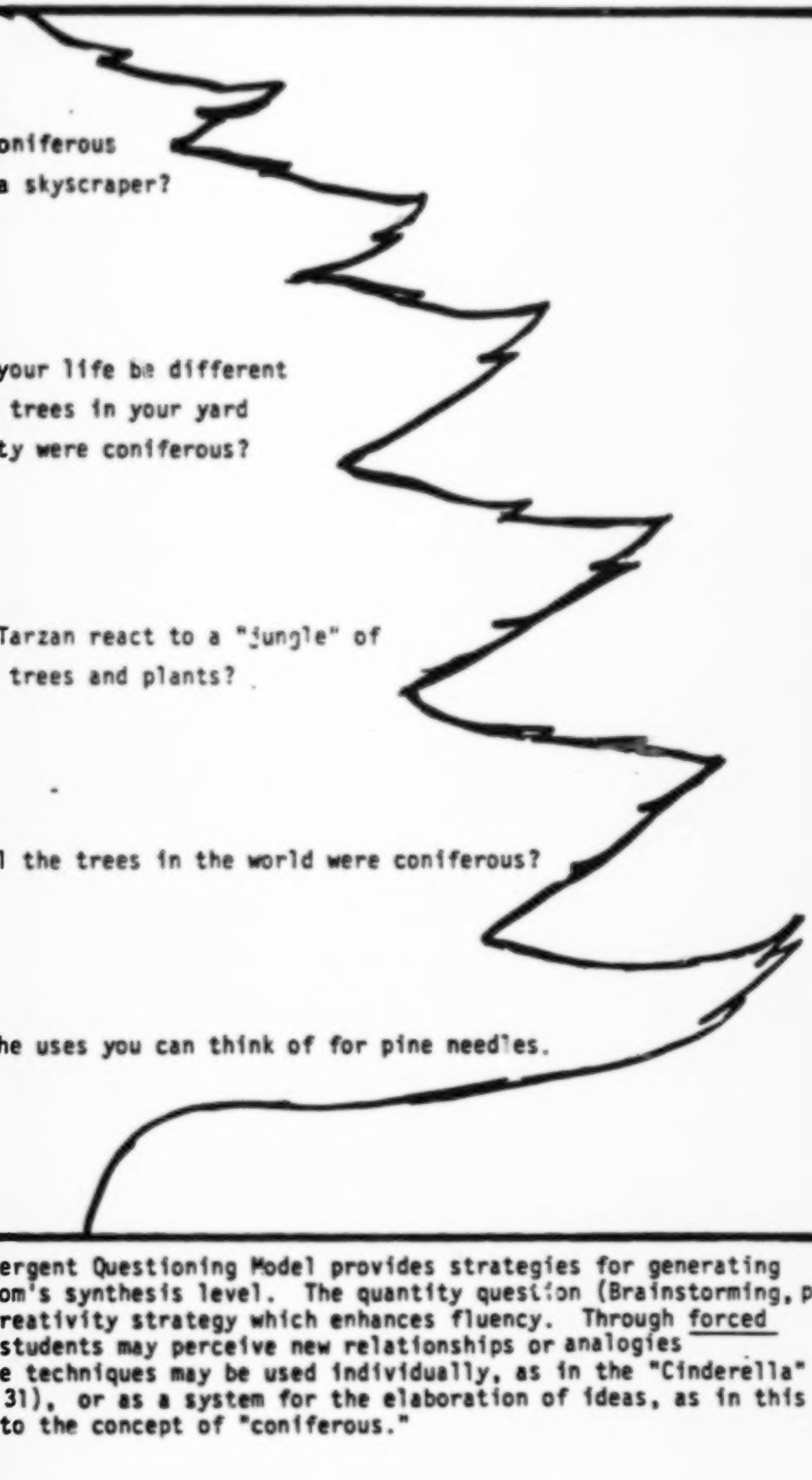
APPLICATION OF THE DIVERGENT QUESTIONING MODEL TO THE DEVELOPMENT OF A SINGLE CONCEPT



FORCED ASSOCIATION

How is a coniferous tree like a skyscraper?

INVOLVEMENT

How would your life be different if all the trees in your yard or community were coniferous?

VIEWPOINT

How would Tarzan react to a "jungle" of coniferous trees and plants?

SUPPOSITION

What if all the trees in the world were coniferous?

QUANTITY

List all the uses you can think of for pine needles.

The Divergent Questioning Model provides strategies for generating ideas at Bloom's synthesis level. The quantity question (Brainstorming, p. 115) is a basic creativity strategy which enhances fluency. Through forced association, students may perceive new relationships or analogies (p. 125). The techniques may be used individually, as in the "Cinderella" examples (p. 31), or as a system for the elaboration of ideas, as in this application to the concept of "coniferous."

SAMPLE QUESTIONS USING THE DIVERGENT QUESTIONING MODEL

CINDERELLA

FORCED ASSOCIATION

How is the story of Cinderella like that of Sleeping Beauty?

How is the fairy godmother like a guidance counselor?

How is the glass slipper like a fingerprint? A license plate? A science test?

INVOLVEMENT

If you were to see your fairy godmother, what would you do?

How would the glass slipper feel if it were human and had feelings?

Describe your feelings as you imagine yourself to be Cinderella at the stroke of midnight.

VIEWPOINT

How would the events of the ball look to a newspaper reporter?

How would Cinderella's father feel about the problems she was having?

Tell the story from the stepsisters' point-of-view.

SUPPOSITION

Suppose the fairy godmother was really an evil witch in disguise. What might be her motive in getting Cinderella to the ball?

How would the story be different if one of the stepsisters had been kind to Cinderella?

What if Cinderella's gown had changed to rags in the ballroom?

QUANTITY

List all the different reasons why Cinderella might not want to go to the ball.

What are all the possible solutions you can think of to improve Cinderella's life style?

List all of the ways in which the Prince could attempt to find Cinderella.

APPLICATION OF THE DIVERGENT QUESTIONING MODEL

OBJECTIVE: The student will apply the Divergent Questioning Model as a strategy for elaboration of creative responses.

PROCEDURE:

1. Present a problem from social studies or science, such as: What could we do with all the waste we produce?

2. Use a brainstorming technique and/or SCAMPER to list a variety of ideas (p. 129).

3. Have the students work in small groups or in pairs to identify at least three categories into which the ideas could be grouped. Students should be able to explain why they have grouped the ideas under a particular category. Possible categories could include:

    - Creative
    - Common
    - Possible
    - Not possible with present technology
    - Supernatural.

4. Have the students select their most creative ideas and construct questions using the Divergent Questioning Model, p. 20, as a method for elaboration.

EXAMPLE IDEA: Trash could be sold.

- Quantity - List all the people who would be interested in buying trash.
- Supposition - What if the things you needed to meet your basic needs could be purchased only from a refuse store?
- Viewpoint - How would selling trash be viewed by the medical professional?
- Involvement - How would you feel if you were a refuse engineer and could no longer collect trash?
- Forced Association - How can we use advertising to promote the sales of trash?

5. Discuss additional ways in which the Divergent Questioning Model can be used to develop questions which facilitate:

    - Elaboration of original ideas and products
    - Evaluation and appreciation of the creative process in
        - The performing arts
        - Writing style
        - Scientific discoveries
        - Current events.

TRI-LEVEL REVIEW OF QUESTIONING

A. **Directions:** To review the three levels of questioning, read the short selection, and identify each item as LITERAL (L), CRITICAL (CR), or CREATIVE (CV).

Selection: As she raced her battered automobile down the busy street, Monica was momentarily blinded by the intense rays of the rising sun.

____ 1. Who was driving the automobile?

____ 2. List all the reasons why Monica was driving fast.

____ 3. What time of day was it?

____ 4. In what direction was Monica traveling? Explain.

____ 5. Was Monica in a race? Explain.

____ 6. Was Monica a good driver?

____ 7. Did Monica become blind?

____ 8. Compare the condition of the car with her driving style.

____ 9. How would a police officer view Monica's driving behavior?

____10. What would Monica's car say if it could talk?

ANSWERS: 1) L, 2) CV, 3) L, 4) CR, 5) CV, 6) CV, 7) L, 8) CR, 9) CV, 10) CV.

B. **Directions:** Read the following selections and prepare at least two questions at each level for each selection.

1. In the distance, Sherlock Holmes could hear the chimes on the old church tower strike seven times.
   "I must follow these footprints while there is still enough light to see," he thought. "The robber must not get away!"

2. With a rapid flick of his long bushy tail, Sammy forced another walnut into his stuffed cheeks and scurried up to his nest in the tree.

REMINDERS FOR EFFECTIVE QUESTIONING

- Encourage students to develop a tolerance for questions which do not have a single right answer.

- Recognize that the concept of "wait-time" by the students, as well as the teacher, may be critical to fostering a questioning climate.

- Arrange seating so that eye contact will facilitate student-student interaction.

- Re-evaluate and analyze the quality of questioning by the students and the teacher periodically.

- Model the kinds of questions the students should be using.

- Make sure the questions using the key words of question starters are eliciting the kinds of responses appropriate for the level desired. The term, classify, is usually associated with the analysis level; however, alphabetizing is a way of classifying items that does not involve higher levels of thinking.

- If students are not responding appropriately at higher levels, it may be necessary to develop understanding by asking questions at a lower level before moving on.

- Encourage student-student interaction by providing opportunities for paired groupings or small group processing during which students may think out loud as in the Think-Pair-Share procedure.

- Provide opportunities for student-led discussions.

- Help students to recognize that active listening skills contribute to good questioning.

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CRITICAL THINKING: OVERVIEW

- Critical Thinking: Semantics, Logic, Authenticity
  - Definitions
  - Objectives from Scope and Sequence
- Teacher Self-Evaluation
- Sample Lessons
  - Format
    - . Skill(s) from Scope and Sequence
    - . Differentiated Objective
    - . Materials for the Lesson
    - . Skill Instruction
    - . Application of Skill to the Curriculum
    - . Follow-up Activities
    - . Resource Materials for Extension
    - . Resource/Activity Sheets
- Semantics
  - I. Vague and Precise Language
    - . Resource Sheet, "Elephant Stew"
  - II. Analogies and Figurative Language
    - . Resource Sheet, "Excerpt from Su An"
- Logic
  - I. Perceiving Attributes and Associations
    - . Resource Sheet, "McGillicuddee Mania"
      - Outline of Content Area Applications
      - Examples of Content Area Applications
  - II. Truth-Value Statements
    - . Resource Sheet, "Cinderella"
      - Activity
      - Suggested Answers

(continued)

III. Strength of Arguments

- Resource Sheet, "Distinguishing Between Strong and Weak Arguments"
  - Definitions
  - Examples

IV. Matrix Logic

- Resource Sheet, "Matrix Logic"

- Authenticity

  Fact, Opinion, and Values

  - Resource Sheet, "Stop Taking Us for Fools"

- Bibliography for Critical Thinking Strategies

CRITICAL THINKING

> *Error of opinion may be tolerated when reason is left to combat it.*
> *- Thomas Jefferson*

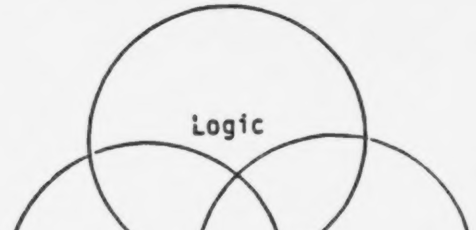
Critical thinking, sometimes referred to as the "Fourth R" (for reasoning), is a complex process which is learned. It involves both convergent and divergent reasoning and extends beyond basic knowledge. The components of critical thinking include:

- Analyzing precise meanings of words and ideas
- Perceiving and inferring relationships
- Weighing facts, values, generalizations, etc.
- Finding the logic within given material
- Creating new products
- Making evaluations.

In reading, critical thinking can be organized into three general skill areas: semantics, logic, and authenticity. Selected skills from the Scope and Sequence of Basic Reading Skills K-6 have been identified for each of these three areas. Sample ideas for possible use with academically talented students have been developed to illustrate the differentiation of several skills.

Although each of the three areas may stand alone, there is an integrated relationship among them. The areas may also be compared to the three major levels of cognition identified in the questioning section.

The importance of effective questioning and metacognition (the conscious analysis of one's thinking) cannot be overstated as prerequisites for teaching and learning critical thinking. Once teachers realize that they have direct control over the kinds of questions posed and discussed and that they control the quantity and quality of students' participation, they can begin to stimulate students to become critical thinkers.



TEACHER SELF-EVALUATION FOR TEACHING CRITICAL THINKING SKILLS

I provide opportunities for my students to:

___ 1. Distinguish between vague and precise words.

___ 2. Recognize the difference between denotative and connotative meanings of words.

___ 3. Recognize propaganda devices, such as name calling, glittering generalities, transfer, testimonial, plain folks, card stacking, and bandwagon.

___ 4. Examine the validity of arguments and judge whether the conclusions are soundly based on the premises.

___ 5. Be aware of the logic of arguments, and teach them to reason through those arguments.

___ 6. Recognize and distinguish between objective and subjective information.

___ 7. Judge the reliability of information by analyzing several viewpoints from a variety of sources on the same topic.

___ 8. Recognize and evaluate the author's purpose, bias, accuracy, and viewpoint.

___ 9. Identify and evaluate the components of literature, such as characterization, plot structure, setting, theme, style, and format.

___ 10. Identify and evaluate literary devices, such as figurative language, symbolism, mood, humor, satire, irony, and point of view.

___ 11. Develop reading strategies appropriate for a specific type of reading material.

___ 12. Analyze a genre of literature or a thematic unit.

SEMANTICS

> *Men imagine that their minds have the command of language, but it often happens that language bears rule over their minds.*
>
> *- Francis Bacon*

Semantics, one of the major skill areas of critical thinking, refers to the ability to understand clearly the meanings of words. The following selected list of skills from the Scope and Sequence of Reading Skills K-6 pertains to semantics. The starred items were selected for development to illustrate differentiation of the basic skill for academically talented students.

SEMANTICS: Literal/Factual

*1. Distinguishes between definite and indefinite terms

*2. Recognizes idiom, simile, metaphor, and personification in a given selection and uses contextual clues to understand their meaning

3. Recognizes word connotations

4. Determines a key word in a question or problem to look for in an index

5. Recognizes the context, purpose, and value of a thesaurus

6. Uses a thesaurus to locate synonyms and antonyms.

SEMANTICS SAMPLE I : Vague and Precise Language

SKILL: Distinguishes between definite and indefinite terms.

DIFFERENTIATED OBJECTIVE: The student will evaluate the effects of vague and precise language on the understanding of information.

MATERIAL: "Elephant Stew," Resource Sheet 2, p. 47.

SKILL INSTRUCTION:

1. Present Resource Sheet 2, "Elephant Stew," to the class.
2. Discuss the recipe's vague points.

   For example:

   - How large is a medium-sized elephant?
   - How large are small bite-sized pieces?
   - Where do you get the gravy?
   - Do you salt and pepper to taste?
   - What is a kerosene fire?
   - Does about four weeks mean one month?

OR

1. Present an actual recipe of your choice.
2. Discuss vague terms that may be included, such as:

   - A pinch of salt
   - Let rise until double in size
   - Stir until smooth
   - Cake is done when center springs back.

APPLICATION:

1. Write a recipe for a variety of audiences: kindergarten (rebus recipe), college science professors, Julia Childs, etc.
2. Have students create vague recipes, descriptions, directions, advertisements, book reviews, etc. Pair students and instruct them to develop at least two different interpretations.

FOLLOW-UP:

1. For further practice, see Harnadek, Critical Thinking: Book I, Exercise 3.4, "A Changed Definition May Produce a Changed Conclusion," and Exercise 5.8, "Glittering Generality."
2. Have students locate advertisements or letters to the editor which contain vague language. Identify vague terms, and explain how and why writers sway our minds by using vague language.
3. Have students create three types of ads for an imaginary product (Super Suds) and explain how each ad would appeal to a different audience.
4. Have students practice writing precise language using any of the topics below. Students should be able to justify the need for precise language.

   - Mathematical computations (flow charts)
   - Programming for computers
   - Directions for dosages of medicine
   - Chemical mixtures (lawn chemicals)
   - Directions for use of home cleaning supplies
   - Traffic signs.

RESOURCE MATERIALS:

Harnedek, Anita. Critical Thinking: Book I - pp. 65-69 and 108-109.
Harnedek, Anita. Critical Thinking: Book II.
Polette, Nancy. Discovery Approaches to Literature with Gifted Students - pp. 10-18.

> *Language, n. The music with which we charm the serpents guarding another's treasure.*
> *- Ambrose Bierce*

Resource Sheet 2

ELEPHANT STEW

1 medium-sized elephant
Salt
Pepper
2 rabbits (optional)

Cut the elephant into small bite-sized pieces. This will take about two months. Add enough gravy to cover. Cook over kerosene fire for abcut four weeks at 438 degrees. If more guests are expected, two rabbits may be added, but do this only in an emergency as most people do not like hare in their stew. Serves 2800.

SEMANTICS SAMPLE II: Analogies and Figurative Language

SKILL: Recognizes idioms, similes, metaphors, and personification in a given selection and uses contextual clues to understand the meaning of the figurative language.

DIFFERENTIATED OBJECTIVE: The student will analyze figures of speech and design a corresponding analogous relationship.

PREREQUISITE SKILLS:

- Identifies and classifies figures of speech.
- Identifies and classifies rules of analogy.

MATERIALS:

- Poem - Excerpt from "Su An" by Doris Johnson, Resource Sheet 3.
- Copies of editorials and political cartoons.

SKILL INSTRUCTION:

1. Review and identify figures of speech and rules of analogy.
2. Select a passage from prose or poetry such as the one found in Resource Sheet 3.

   "My mother's eyes are like two ponds
   at night in which
   the moon swims. But they
   do not spill their tears."

   or

   "Her kiss brushes my cheek lightly
   as a dragonfly's wing
   And she is gone."
3. Discuss ways that the simile can be changed into an analogous relationship.
4. Using Resource Sheet 3, have students design their own analogies. As long as the rules of analogy are maintained, accept the students' responses as correct.

- Some possible responses could be -

  Eyes are to reflecting feelings
  as pond is to reflecting moon
  (object : action)

  Pupil is to eye as reflected moon
  is to pond (part : whole)

  Crying is to eyes as falling
  water is to pond (action : object)

  Tears are to eyes as water is
  to pond (part : whole)

  or

  Kiss is to brush as wing is to touch
  (object : action)

  Mother is to farewell as dragonfly
  is to flight (object : action)

  Kiss is to goodbye as wing is to
  flight (object : use)

APPLICATION:

Allow time for students to work independently, or in pairs, to select additional examples of figurative language in newspapers and/or magazines. Have them rewrite their examples in the form of an analogy.

FOLLOW-UP:

1. Locate a political cartoon which uses figurative language or symbolism. Students may wish to create original cartoons containing the same symbolism.
2. Listen to the lyrics of songs or poems, such as "Bridge Over Troubled Water" by Simon and Garfunkel or "Annie's Song" by John Denver. Other songwriters or poets to consider are Don McLean, Mac Davis, Neil Diamond, Harry Chapin, and Carole King. Students may also select popular songs which contain appropriate lyrics. Have the students identify examples of similes, metaphors, and idioms, and have them explain the analogous relationships.

3. Evaluate the use of figurative language and analogies as support for opinions and points of view in editorials, reviews, and letters to the editor. Opinion papers incorporating original analogous relationships may be developed.

4. Analyze the use of figurative language and analogies as demonstrated by propaganda and persuasive techniques in advertisements. Students may develop original advertisements using figurative language and analogies.

5. Make a collection of maxims, adages, and/or cliches, such as "Necessity is the mother of invention." Which of the sayings and corresponding relationships can be classified as simile, metaphor, or personification? Identify the analogical relationships.

6. Analyze allegories, such as Aesop's fables. In what ways are the events in such fables analogous to present-day situations? Additional examples can be found in modern fables, such as James Thurber's "The Owl Who Thought He Was God" in the Junior Great Books program.

7. Analyze the figurative language in mottoes for states, cities, and/or institutions. Students may wish to create a class motto or personal mottoes for this activity.

RESOURCE MATERIALS:

Boning, Richard A. Discovering Word Patterns: Intermediate and Advanced.

Boning, Richard A. Recognizing Word Relationships: Intermediate and Advanced.

Draze, Dianne. Thinking Through Analogies.

Innovative Sciences. Introducing Thinking Skills Teacher's Manual. pp. 120-142.

Post, Beverly and Sandra Eads. Logic Anyone? pp. 5, 11-13.

> *The greatest thing by far is to be the master of metaphor.*
>
> *- Aristotle*

Resource Sheet 3

Excerpt From "Su An"
by
Doris Johnson

My mother's eyes are like two ponds
at night in which
the moon swims. But they
do not spill their tears.
Her voice is like the soft song of a
bamboo flute
and the steady presence of stones
in a garden.
"Peace little Su An," the
picture speaks.
"I must go away,
so I leave you here with Madame Kim.
She will take good care of you."
My mother's lips are like blossoms
trembling in a soft breeze.
"My heart will always be with you,"
she whispers.
"I promise."
Her kiss brushes my cheek lightly
as a dragonfly's wing.
And she is gone.

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Johnson, Doris."Su An." Follett Publishing Company. 1968. Reprinted in full in Free Rein published by Allyn and Bacon (Level 16), 1978; and in Questionary published by Addison Wesley (Grade 5), 1982.

LOGIC

> *Life is the art of drawing sufficient conclusions from insufficient premises.*
> *- Samuel Butler*

The use of logic is a key component in developing critical thinking skills. Logic may be defined as the science which investigates principles governing correct and reliable inference. The following selected list of skills from The Scope and Sequence of Reading Skills K-6 pertains to logic. The starred items were selected to illustrate differentiation of the basic skill for academically talented students.

LOGIC: (Critical/Inferential)

1. Uses details to prove or refute a statement
2. Identifies details needed to solve a problem
3. Relates information to a previous experience with a similar theme
4. Rearranges events to develop an accurate sequence

*5. Perceives associations (time, place, cause and effect)

6. Obtains information implied in pictures
7. Compares and contrasts reactions among characters
8. Predicts outcomes

*9. Draws conclusions

10. Interprets the mood of a situation, story, or poem
11. Identifies ideas implied but not directly stated
12. Determines the most appropriate action in a given situation

*13. Assesses the adequacy of information to support a conclusion

14. Determines the main idea of an experience, a picture, or a story

*15. Classifies terms, facts, and ideas under headings or in categories

16. Makes an outline including subtopics and details to summarize information from one or more references

*17. Differentiates between relevant and irrelevant information.

LOGIC SAMPLE I: Perceiving Attributes and Associations

SKILLS: Perceives associations.

Classifies terms.

Differentiates between relevant and irrelevant information.

DIFFERENTIATED OBJECTIVES: The student will perceive associations through the analysis of attributes.

MATERIAL: "Mc Gilliccuddee Mania," Applications for Analysis of Attributes," Resource Sheet 4, p. 59.

Note: "McGilliccuddee Mania" is a strategy for identifying the attribute rule for a group of items or terms; hypothesis testing, pattern recognition, making generalizations, and drawing conclusions are involved in the process. "McGilliccuddee Mania" can be applied to all subject areas as demonstrated in Resource Sheet 4. The following list shows a variety of instructional purposes for which it can be used:

. Provide motivation

. Warm-up

. Introduce specific concept/objective

. Develop student-student interaction

. Develop listening skills

. Develop thinking skills

. Drill

. Review

. Have fun!

SKILL INSTRUCTION:

1. Introduce the students to "McGilliccuddee Mania." (The following suggested procedure demonstrates the double letter rule.)

Explain: I have a friend named Miss McGilliccuddee whom I'd like you to know. She is rather eccentric and has peculiar tastes. She uses a rule to decide what she likes and dislikes.

- She likes puppies, but not dogs.
- She likes kittens, but not cats.

Ask: Can someone give me an example of something else she would like? (Caution the students to give only an example but not the rule because all students should have to discover the rule for themselves.)

Student Response: She likes young, but not old.

Teacher Response: She doesn't like either.

Student Response: She likes little, but not big.

Teacher Response: Yes, give another example.

Student Response: She likes babies, but not adults.

Teacher Response: No, she doesn't like either one.

Explain: Remember, she doesn't like young or old. If all the examples do not fit the rule you have in your head, you need to change your rule or hypothesis.

2. Encourage the students to continue to test their hypotheses and to recognize that a "wrong" answer provides information, not failure.

3. If after each student has had a chance to respond, and some are still stumped, direct them to list from memory the terms Miss McGillicuddee likes and dislikes.

Explain: Sometimes we need to take in information in a variety of ways in order to draw conclusions more efficiently.

4. Have the students continue to give examples and to write down the information. Guide the students to identify the rule individually. It may be necessary to list the terms on the board and to provide obvious examples, such as:

   - She likes Mississippi, but not Maryland.
   - She likes bookkeeping, but not math.
   - Her favorite subject in school is spelling; she loves her name, Miss McGillicuddee.

5. Some of the students still may not be able to identify the rule. They should be encouraged to continue thinking, to apply guidelines for problem solving, and to be prepared to continue at another time. Those students who have identified the rule should be cautioned not to give the answer away.

6. When all the students have discovered the answer for themselves, discuss the strategies and problem solving steps they used.

APPLICATION:

1. Provide other attribute rules from Resource Sheet 4 for the students to discover.

2. Have the students create original McGilliccuddee puzzles to share with their classmates.

FOLLOW-UP

1. Have the students develop McGilliccuddee-type rules for spelling list words.

2. Have the students write a mystery story using McGilliccuddee-type clues for the solution.

3. Have the students develop a set of McGilliccuddee-type clues for a treasure hunt.

4. Have the students learn and develop other attribute games which are described in the creativity section, pp. 118-121.

> *My toys were all tools - they still are!*
> *- Henry Ford*

MC GILLICCUDDEE MANIA: APPLICATIONS FOR ANALYSIS OF ATTRIBUTES

I. Reading/Language Arts/Spelling
  A. Rules of Inclusion/Exclusion
    1. Phonic Analysis
      a. Double vowels and/or consonants
      b. Beginning, medial, or final consonant
      c. Digraphs
      d. Diphthongs
      e. Silent e and/or silent letters
    2. Structure Analysis
      a. Compound words
        . Divided
        . Undivided
        . Hyphenated
      b. Syllabication
        . Number of syllables
        . Accented syllable
        . Prefix/suffix
      c. Parts of speech
      d. Homophones
      e. Homographs
      f. Synonyms/antonyms
      g. Number of letters

  B. Rules of Structure/Function
    1. Physical characteristics: soft things, things with handles
    2. Operational characteristics: things that spin, things used as tools
    3. Parts of speech
    4. Meaning/context

  C. Rules of Logical Relationships
    1. Size
    2. Shape
    3. Time
    4. Change
    5. Quantity
    6. Sequence

  D. Rules of Analogy
    1. Part/whole
    2. Action/object
    3. Cause/effect

II. Mathematics

A. Number patterns and classes
1. Odd/even
2. Primes
3. Ordinals
4. Exponential progression

B. Geometry
1. Shapes
2. Lines of symmetry
3. Number of vertices

III. Content Areas

A. Geography
1. Land forms
2. Cities, states, countries
3. Boundary limitations (item limited to a specific political or geographic area)

B. Science
1. Physical and chemical properties
2. Class, phyla
3. Principles

C. Music
1. Rhythmic patterns
2. Key signatures
3. Composers (compositions, periods)
4. Classes of instruments (structure, function)

D. Art
1. Principle or quality
2. Category (form, media, style)

E. Physical Education
1. Team and position components
2. Skills needed, e.g., running sports
3. Contact sports
4. Specific equipment or playing area
5. Rules

MC GILLICCUDDEE MANIA: EXAMPLES

Miss McGilliccuddee likes . . .

I. Reading/Language Arts/Spelling
   A. Spelling
      1. Cat, but not kitten
      2. Dogs, but not puppies
      3. Mississippi, but not Tennessee
      4. Wasps, but not bees
      5. Principals, but not teachers.

   ANSWER: *Miss McG. likes words without the letter "e."*

   B. Function
      1. Refrigerators, but not ice cubes
      2. Ovens, but not baking
      3. Automobiles, but not bicycles
      4. Staplers, but not hammers
      5. Compacts, but not mirrors.

   ANSWER: *Miss McG. likes things that open and hold things.*

Miss McGilliccuddee likes . . .

II. Mathematics
   A. Number patterns and classes
      1. Five, but not six
      2. Three, but not four
      3. Eleven, but not nine
      4. Twenty-three, but not twenty-one
      5. Seven, but not eight.

   ANSWER: *Miss McG. likes prime numbers.*

   B. Geometry
      1. A, but not B
      2. M, but not N
      3. T, but not S
      4. V, but not Z
      5. U, but not Q

   ANSWER: *Miss McG. likes figures that are symmetrical on the vertical axis.*

III. Content Areas
   A. Geography
      1. Mississippi, but not Missouri
      2. North Carolina, but not North Dakota
      3. Pennsylvania, but not Wisconsin
      4. Maryland, but not Texas
      5. Maine, but not Washington.

   ANSWER: *Miss McG. likes any state east of the Mississippi River.*

   B. Science
      1. Geese, but not chickens
      2. Swans, but not penguins
      3. Egrets, but not emus
      4. Pheasant, but not turkey
      5. Canaries, but not kiwis.

   ANSWER: *Miss McG. likes birds that fly.*

   C. Music
      1. Johann Sebastian Bach, but not Johannes Brahms
      2. Georg Friedrich Handel, but not Franz Joseph Haydn
      3. Johann Pachelbel, but not Giacomo Puccini
      4. Vivaldi, but not Vangelis
      5. Domenico Scarlatti, but not Gioacchino Rossini.

   ANSWER: *Miss McG. likes baroque period composers.*

   D. Art
      1. Michelangelo, but not Botticelli
      2. Da Vinci, but not Raphael
      3. Rodin, but not Manet
      4. Gutzon Borglum, but not Bosch
      5. Sir Jacob Epstein, but not Picasso.

   ANSWER: *Miss McG. likes sculptors and not painters.*

LOGIC SAMPLE II: Truth-Value Statements

SKILL: Assesses the adequacy of information to support a conclusion.

DIFFERENTIATED OBJECTIVE: The student will assess the adequacy of information to support a conclusion by using truth-value statements.

PREREQUISITE SKILLS:

- Draws conclusions.
- Distinguishes between vague and precise words.
- Distinguishes between fact and fiction.

MATERIALS: "Cinderella," Resource Sheet 5, p. 69.

BACKGROUND: FACT: A point of information which can be proven or disproven by evidence. Therefore, a fact may be proven to be true or false.

TRUTH-VALUE: The truth or falsehood of a proposition or statement. In logic, a given selection is assumed to be true, and statements made about the selection are analyzed for the valid elements that make the statements true.

QUESTIONABLE STATEMENTS: Statements which cannot be proven true or false with the information available.

SKILL INSTRUCTION:

1. Have the students read the story and complete the activity on "Cinderella," Resource Sheet 5, p. 69.
2. Allow the students to discuss their answers freely. Remind students that in thinking critically they must:
   - Accept the story as true.
   - Use only the text of the story.
   - Assume the story uses standard English usage.
   - Eliminate preconceived notions or emotions from their reasoning.

Possible responses to the first three items:

- You can conclude that Cinderella had more than one stepsister since the word stepsisters is the plural form.
- You cannot conclude that Cinderella 's natural mother is dead because her parents may be divorced or may belong to a religion which permits having more than one spouse. Therefore, the statement is questionable since not enough information is given to draw a conclusion.
- The third statement is questionable because the terms many and all are vague. Although it is true that they went to "all of the important events," it is possible there was only one important social event each year. Therefore, one may not conclude that all is equivalent to many.

3. Encourage the students to challenge one another's answers and to be prepared to support their own answers. Answers which can be logically supported from resources available, such as the dictionary, should be accepted as correct even if you find disagreement with the answer key. (See #12 in the "Answers and Explanations" sheet from Resource Sheet 5.)

APPLICATION:

1. Prepare a similar exercise based on a selection from the students' assigned reading material. A model for adapting this concept to a basal reader selection follows:

TRUTH-VALUE STATEMENTS AND CONCLUSIONS

Directions: 1. Read the story and assume that it is true.

2. Write T for true, F for false, or Q for questionable to show if the statements can be used to support a conclusion about the story.

Material: "Journey into Jazz" by Natt Hentoff in Outlets, Macmillan Publishing Company, New York, 1975, p. 47-49 (Grade 5).

___1. Peter put a sign on his door everyday.

___2. Peter played a trumpet before he took lessons.

___3. His parents enjoyed his modern music.

___4. Before he was fourteen, Peter was better than his teacher on the trumpet.

___5. Peter was able to read any printed music.

2. Have students examine each other's written work in reading and other subjects to determine if they have expressed conclusions appropriately in terms of the truth-value type of analysis.

FOLLOW-UP:

1. Have the students write truth-value statements about selections from assigned reading, content reading, newspaper articles, editorials, etc.

2. Introduce syllogisms (if-then statements) as a way to further evaluate the adequacy of information to support a conclusion.

3. Drawing on various content areas, have the students use truth-value concepts to solve table logic problems and to create original problems. Students should be required to supply adequate information to support the solutions to their problems. For further information, see Logic, Anyone?, pages 58-60.

RESOURCE MATERIALS:

Baker, Michael, Syllogisms.

Harnadek, Anita, Critical Thinking Book I, pages 36-41.

Harnadek, Anita, Critical Thinking Book II, page 2-38, 115-132.

Harnadek, Anita, Logic in Easy Steps Book I.

Post, Beverly and Eads, Sandra, Logic Anyone!, pp. 75-80, 99-105.

> *To have doubted one's own first principles is the mark of a civilized man.*
> *- Oliver Wendell Holmes*

Resource Sheet 5

Page 1

CINDERELLA

DIRECTIONS: Read the story and assume that it is true. Decide if the statements following the story can be used to support a conclusion about the selection by indicating True (T), False (F), or Questionable (Q).

Cinderella's stepmother and stepsisters disliked her. They bought themselves beautiful clothes and gifts and went to all of the important social events, but Cinderella wore rags and had to stay home. On the night of the Prince's ball, the stepmother and stepsisters wore beautiful gowns and jewels, and they left Cinderella home to clean the fireplace. But Cinderella's fairy godmother appeared, and she turned Cinderella's rags into a beautiful gown. Then the fairy godmother, whose powers were granted to her for all eternity, found a pumpkin, turned it into a gold-plated automobile, and turned a mouse into a chauffeur. Cinderella rode to the Prince's ball in grand style.

___ 1 Cinderella had more than one stepsister.

___ 2 Cinderella's natural mother was dead.

___ 3 The stepmother and stepsisters went to many social events.

___ 4 Cinderella's stepmother and stepsisters didn't buy any beautiful clothes for Cinderella.

___ 5 A pumpkin can't be turned into a gold-plated automobile.

___ 6 The stepmother and stepsisters disliked Cinderella.

___ 7 Cinderella's stepmother or stepsisters made Cinderella stay home when they went to the important social events.

___ 8 The stepmother and stepsisters offered to take Cinderella to the Prince's ball with them.

___ 9 Cinderella walked to the Prince's ball.

___ 10 Cinderella wanted to go to the Prince's ball.

___ 11 The stepmother and stepsisters left Cinderella home on the night of the Prince's ball.

___ 12 Cinderella rode to the Prince's ball in a carriage drawn by six white horses.

___ 13 Although the stepmother and stepsisters had beautiful clothes, they never bought any clothes for themselves.

___ 14 The stepmother and stepsisters went only to social events which were important.

___ 15 Cinderella's fairy godmother was an evil witch in disguise.

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TRUTH VALUE ANSWERS AND EXPLANATIONS

I 1. Cinderella had more than one stepsister.

Line one - stepsisters

Q 2. Cinderella's natural mother was dead.

Insufficient information in the text to draw a conclusion. Possible explanations for the natural mother's whereabouts could include: held captive, ran away, divorced, under a magic spell.

Q 3. The stepmother and stepsisters went to many social events.

Support appears to be in line two, "went to all the important social events." No conclusions due to indefinite terms all and many; also, important is an imprecise term involving personal judgment. For example, all could be one event a year.

Q 4. Cinderella's stepmother and stepsisters didn't buy any beautiful clothes for Cinderella.

Insufficient information in the text. Possible explanations for Cinderella wearing rags could include: she liked rags; the rags were the original clothes her natural mother gave her; she was a hippie; her stepmother bought her clothes but forbade her wearing them; she had good clothes but didn't want to get them dirty.

F 5. A pumpkin can't be turned into a gold-plated automobile.

Line eight - "found a pumpkin and turned it into a gold-plated automobile . . . ." The conclusion is based on the condition that the reader assumes the story to be true.

I 6. The stepmother and stepsisters disliked Cinderella.

Line one

Q 7. Cinderella's stepmother or stepsisters made Cinderella stay home when they went to the important social events.

Support appears to be in line three, "had to stay home." It is not clear whether Cinderella had to stay home because she was forced to by her stepmother or because she had a personal reason which compelled her to stay home. Perhaps she had to stay home because she did not have any beautiful clothes. (See the explanation for #4)

Q 8. The stepmother and stepsisters offered to take Cinderella to the Prince's ball with them.

Insufficient information. It is possible that they offered to take her only to be sarcastic.

F 9. Cinderella walked to the Prince's ball.

Line nine

Q 10. Cinderella wanted to go to the Prince's ball.

Insufficient information to draw a conclusion.

T 11. The stepmother and stepsisters left Cinderella home on the night of the Prince's ball.

Line five

Q 12. Cinderella rode to the Prince's ball in a carriage drawn by six white horses.

Harnadek's answer is Q, however, it could be argued that the complete sentence supports the idea that the automobile driven by a chauffeur, which means the operator of a motor vehicle, conveyed Cinderella to the ball. Therefore, this statement could also be false.

F 13. Although the stepmother and stepsisters had beautiful clothes, they never bought any clothes for themselves.

Lines one and two

Q 14. The stepmother and stepsisters went only to social events which were important.

Insufficient information. The key word here is only.

Q 15. Cinderella's fairy godmother was an evil witch in disguise.

Insufficient information to draw a conclusion at this time.

LOGIC SAMPLE III: Strength of Arguments

SKILL: Differentiates between relevant and irrelevant information.

DIFFERENTIATED OBJECTIVE: The student will analyze the strength of arguments on the basis of relevant and irrelevant information.

PREREQUISITE SKILLS:

- Distinguishes between relevant and irrelevant information.
- Understands what constitutes a strong argument and a weak argument.

MATERIALS:

- "Distinguishing Between Strong and Weak Arguments," Resource Sheet 6, p. 77.
- Harnadek, Anita, *Relevant Information: Inductive Thinking Skills*.
- Appropriate letter to the editor.

SKILL INSTRUCTION:

1. Review concept of relevant and irrelevant information.

   - Have students discuss and analyze situations in Anita Harnadek's *Relevant Information: Inductive Thinking Skills*.

   OR

   - Present math problems containing extraneous information, and have the students identify the information that does not contribute to the solution of the problem.

2. Have students discuss the definitions for weak and strong arguments given in *Critical Thinking Book II*, section 7.1, p. 170, "Distinguishing Between Strong and Weak Arguments," noting in particular those points relating to relevancy. Have students discuss a problem in the chapter, if necessary. See Resource Sheet 6, p. 77.

3. Present an example of a statement which has one supportive argument and one nonsupportive argument. Have the students discuss the differences.

   Statement: Power companies should not build more nuclear power plants.

   Supportive Argument: The nuclear waste from plants already built is difficult to store and has caused health hazards.

Non-Supportive Argument: No one wants to live near a nuclear power plant.

Students should recognize that since supportive arguments are relevant to the issue, they contribute to the strength of the overall argument.

APPLICATION:

1. Present, or have students select, an editorial or a letter to the editor. Students should identify the issue presented, analyze the relevancy of the statements, and present the information in chart form.

Issue	
Relevant Statements	Irrelevant Statements

2. Have the students discuss and explain why they have judged certain statements as relevant or irrelevant.

3. Based on their analysis of the statements, have the students decide whether the argument is strong or weak.

4. Have the students write supportive statements which are relevant to the argument.

FOLLOW-UP:

1. Have the students develop additional supportive statements to strengthen the argument presented in the preceding application section.

2. Present a list of debatable questions. Have students work in pairs to select a question and prepare to argue the question in front of the class. Teachers may wish to review Critical Thinking Book I, section 8.6, "Debating."

   Possible questions to debate -

   - Should George Washington be considered a better president than Abraham Lincoln?
   - Should laws governing drunk drivers make them more accountable for their actions?
   - Should professional athletes be entitled to receive high salaries?
   - Should advertisers be allowed to target their ads toward children?

DISTINGUISHING BETWEEN STRONG AND WEAK ARGUMENTS

We often hear people discussing different sides of an issue. It is important to be able to tell which arguments (statements they make) are strong and which arguments are weak. An argument may have a strong emotional appeal and yet be a weak argument. Or an argument may state a very important fact and yet be weak because the fact stated has little to do with the question being argued.

We want to be careful not to think an argument is strong just because we agree with the side it favors. And we want to be careful not to think an argument is weak just because we disagree with the side it favors. In other words, we want to train ourselves to put our personal feelings aside when we decide whether an argument is strong or weak.

We will say an argument is strong if

1. It is true, and
2. It is directly related to the question, and
3. It is important, in view of the overall issue raised by the question.

We will say an argument is weak if

1. It is false, or
2. It ignores conditions stated by the question, or
3. It is not directly related to the question, or
4. It concentrates on only minor parts of the question, or
5. It is not important, in view of the overall issue raised by the question.

For this section, we will assume that all arguments given in examples and the problems are true. Then we won't have to worry about items (1) in the two lists above.

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Distinguishing Between Strong and Weak Arguments

Example 1:

Should schools have dress codes?

(1) Yes. Students today have too much freedom. (Weak. The statement is too general to be directly related to the question.)

(2) No. Not everyone can afford uniforms. (Weak. The question does not imply that uniforms would be required.)

An argument may be strong even though it has flaws. Remember, we said we would assume that each argument given is true.

Example 2:

Should schools have dress codes?

(1) Yes. Certain kinds of clothing (such as swim wear) are totally out of place in school and should not be allowed. (Strong. A dress code would elminate "out of place" clothing. But who would decide what is out of place and what is not? One person might think that jeans are OK for school, but another might think they're not.)

(2) No. Schools don't need dress codes. (Strong. But it will not convince most opponents to change their minds. For these opponents, the argument begs the question—uses the circular reasoning. Even though we accept the statement as true, these opponents base their "yes" answers on, "A dress code is needed, because . . ." To these opponents, the argument merely says, "A dress code is not needed because it is not needed." To convince these opponents, the argument would have to tell why a dress code is not needed.)

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Critical Thinking: Book II. Pacific
Grove, California: Midwest Publications
Company, Inc. 1979, p. 170.

LOGIC SAMPLE IV: Matrix Logic

SKILLS:

- Classifies terms, facts, and ideas under headings or in categories.
- Distinguishes between definite and indefinte terms.
- Draws conclusions.

DIFFERENTIATED OBJECTIVE: The students will use matrix logic to classify terms in order to draw a conclusion.

PREREQUISITE SKILLS:

- Distinguishes between vague and precise words.
- Rearranges events to develop an accurate sequence.
- Differentiates between relevant and irrelevant information.

MATERIALS:

- "Matrix Logic," p. 87, Resource Sheet 7.
- Transparency of Resource Sheet 7.
- Harnadek, Anita. Mindbenders A1, A2, A3, or A4.

BACKGROUND: Matrix logic is a deductive strategy which uses the process of elimination to identify corresponding facts and to draw conclusions. It demonstrates the use of a model or diagram as a strategy for organizing complex information. Logic problems may also be solved using other strategies, such as Venn Diagrams, illustrations, or lists.

SKILL BACKGROUND:

1. Project only the top portion of the resource sheet containing the word problem and have students attempt to solve it within three to five minutes.
2. Allow the students an opportunity to share answers and/or frustrations verbally.

3. Project the chart.

   - Explain that the chart is called a matrix and can be used to organize the kind of information given in the problem.

   - Distribute copies of Resource Sheet 7 .

   - Emphasize the need for students to follow the step-by-step procedure with the teacher.

4. Read and analyze the first clue.

   - Ask: If Joan is not working inside the restaurant, then which job or jobs will be eliminated?

     Response: Joan cannot be busboy, chef, or waiter.

   - Using the transparency, place an "X" on the row for Joan where it matches each of the jobs mentioned. Have the students follow along with their copies.

	Busboy	Chauffeur	Chef	Waiter
Francis				
Gayle				
Joan	X		X	X
Mirvin				

   - Ask: What must Joan's job be?

     Response: If chauffeur is the only space left, then Joan must be the chauffeur.

   - Place an "O" in the space where Joan and chauffeur intersect.

   - Ask: If Joan is the chauffeur, can anyone else be the chauffeur?

     Response: No.

   - Place an "X" under chauffeur for each of the remaining names.

	Busboy	Chauffeur	Chef	Waiter
Francis		X		
Gayle		X		
Joan	X	0	X	X
Mirvin		X		

. Ask: Is there any other information that can be obtained from this clue at this time?

Remind students that it may be necessary to return to this clue as other information is revealed.

5. Read and analyze the second clue.

. Place an "X" under busboy or Francis.

. Ask: Can you make any further eliminations with the information given?

. Ask: How can you conclude whether Gayle or Mirvin is the busboy?

Response: Since Gayle is a girl, she cannot be a busboy.

. Place an "X" where Gayle and busboy match.

. Help students to conclude that Mirvin must be the busboy and place a circle where these terms meet; also place an "X" to eliminate chef and waiter for Mirvin.

	Busboy	Chauffeur	Chef	Waiter
Francis	X	X		
Gayle	X	X		
Joan	X	0	X	X
Mirvin	0	X	X	X

6. Have students review the information and the incomplete chart.

   . Ask: Can you decide whether Francis or Gayle should be the chef or the waiter?

   Response: Yes, because Francis is a man's name, and we say waiter for a man and waitress for a woman.

   Place an "O" where Francis and waiter meet; place an "X" in the remaining block.

   Have the students list the corresponding facts and recheck them to make sure that they satisfy the conditions of the problem.

Francis:	Waiter
Gayle:	Chef
Joan:	Chauffeur
Mirvin:	Busboy

APPLICATION:

1. Provide comparable problems from the bibliography of resources for the students to solve independently. Review the step-by-step procedure as needed.

2. Have the students discuss and analyze concepts such as the following, which they need to be aware of in order to solve the problems:
   - Distinguishes between definite and indefinite terms
   - Uses details to prove or refute a statement
   - Rearranges events to develop an accurate sequence
   - Perceives associations (time, place, cause and effect)
   - Assesses the adequacy of information to support a conclusion
   - Differentiates between relevant and irrelevant information.

3. Use the Think-Pair-Share procedure as a way to analyze the kinds of questions students need to ask, in order to solve the problems effectively.

4. Guide students to appreciate matrix logic, or comparable logic problems, as a way to sharpen thinking skills. Students should be aware that matrix logic is not just a game.

FOLLOW-UP:

1. Have students construct original charts for Mindbender problems.
2. Increase the level of difficulty of the problem.
3. Create a station or center where matrix logic problems are available on an ongoing basis.
4. Have the students create original logic problems using content area topics. Logic, Anyone? provides step-by-step guidelines for developing original problems.
5. Have the students apply and discuss the problem solving guidelines they needed to use in solving matrix logic problems.

RESOURCE MATERIALS:

Burge, Susan. Challenger Logic : Primary. St. Louis, Missouri: Milliken Publishing Company, 1984.

Games. (Magazine) 515 Madison Avenue, New York, New York 10022.

*Harnadek, Anita. Mind Benders : Levels A and B . Pacific Grove, California: Midwest Publishing Company, 1979.

Post, Beverly and Sandra Eads. Logic, Anyone? Belmont, California: Pitman Learning, Inc., 1982.

Powers, Tinian. Challenger Logic: Intermediate. St. Louis, Missouri: Milliken Publishing Company, 1984.

Ross, Cathy. Cognitive Challenge Cards. Novato, California: Academic Therapy Publications, 1978.

Williams, Wayne. Quizzles . Palo Alto, California: Dale Seymour Publications, 1982.

______. More Quizzles. Palo Alto, California: Dale Seymour Publications, 1982.

* Note: C Level puzzles are not recommended for in-class instruction, but as optional challenge activities for students who enjoy this type of problem.

MATRIX LOGIC

Francis, Mirvin, Joan, and Gayle are two men and women who hold the positions of busboy, chauffeur, chef, and waiter. From the clues below, match each person's name and occupation.

1. Joan is not working inside the restaurant.
2. Francis is not the busboy.

	BUSBOY	CHAUFFEUR	CHEF	WAITER
FRANCIS				
GAYLE				
JOAN				
MIRVIN				

AUTHENTICITY

> *The folly of mistaking a paradox for a discovery, a metaphor for a proof, a torrent of verbiage for a spring of capital truths, and oneself for an oracle, is inborn in us.*
>
> *- Paul Valèry*

Authenticity, the third component of critical thinking, involves judging the validity of information. The following list of selected skills from The Scope and Sequence of Reading Skills K-6 pertains to authenticity. The starred item was selected to illustrate differentiation.

Authenticity: Creative/Evaluative

1. Forms questions about events
2. Uses questions about events
3. Evaluates information and sources in relation to purposes
4. Compares information about a topic drawn from two or more sources
5. Differentiates between primary and secondary sources
6. Identifies an author's purpose, evidence, and objectivity

*7. Evaluates the validity of information (copyright date, author's bias, comparison with other sources, use of mass persuasion techniques).

AUTHENTICITY SAMPLE: Fact, Opinion, and Values

SKILL: Evaluates the validity of information (copyright date, author's bias, comparison with other sources, use of persuasion techniques).

DIFFERENTIATED OBJECTIVE: The student will evaluate the validity of information by examining the use of facts, opinions, and values.

PREREQUISITE SKILLS:

- Differentiates between fact and opinion.
- Recognizes vague or precise language.
- Recognizes persuasive techniques.

MATERIAL:

- Norris M. Sanders, Classroom Questions: What Kinds?
- "Stop Taking Us for Fools," Resource Sheet 8, p. 93.

SKILL INSTRUCTION:

1. Review the difference between fact and opinion. Remind the students that a fact is a statement which can be proven or disproven as true.
2. Discuss the meaning of the term values and facilitate the development of an operational definition which includes the concept that values are standards of right and wrong or judgments of good and bad which "cannot be proven to be true by logical or scientific process" (Sanders, p. 145, also see pp. 24-25).
3. Compare the definitions of fact, opinion, and value. Develop the concept that all values are opinions since values cannot be proven to be true, but that not all opinions are values since "opinions often result from lack of access to information or take the form of predictions" (Sanders, p. 145).
4. Have students identify fact, value, and opinion in exercises such as the ones found in Sanders, pp. 53-54, or the ones below:
   - The ideal source of energy is the sun. (Opinion)
   - If we stop wasting energy, it will be good for people and good for our natural heritage. (Value)
   - Surface (strip) mining destroys the land and everything that grows on it. (Fact)

5. Have students read an article, such as "Stop Taking Us for Fools," Resource Sheet 8. Identify statements as fact, opinion, or value based upon the established criteria.

6. Discuss the definition and characteristics of a valid argument:

   . Definition according to Harnadek —

   > If the conclusion absolutely must follow from the premises, then the argument is valid. On the other hand, if the conclusion does not necessarily have to follow from the premises, then the argument is invalid.
   >
   > (Critical Thinking, Book II, p. 49)

   . Characteristics of a valid argument include:

   - Facts are reliable, that is, they can be documented or confirmed.
   - Facts may be accepted as true conditionally.
   - Opinions are supported by facts and formed logically.
   - Values that are expressed are not used for support.
   - An argument which cannot be proven invalid must be accepted as valid.

7. Have the students identify the major argument presented by Charlie Simmons in Resource Sheet 8.

8. Discuss how the facts, opinions, and values contribute to making the argument valid or invalid.

FOLLOW-UP:

1. Explore the concept of values further by completing activities such as those found in Anita Harnadek's Critical Thinking Book I, Chapter 1, "Introduction to Critical Thinking," pp. 1-25, and Chapter 7, "Examining Arguments and Value Judgments," pp. 136-155.

2. Have students analyze the values displayed by Jack, his mother, and the Giant in "Jack and the Beanstalk," Fact, Fantasy, and Folklore, pp.75-84.

3. Have students analyze the validity of facts and the impact of mass persuasion in "Henny Penny," Fact, Fantasy, and Folklore, pp. 85-97.

4. Have students analyze arguments of their choice from printed news media, such as U.S. News and World Reports, "Pro and Con," and re-write the argument using their own opinions and values based on new or updated facts.

5. Have students watch television newscasts or talk shows such as Square-Off, People Are Talking, Donahue, 60 Minutes, or 20/20, and analyze the elements of an argument or issue presented.

6. Have students analyze and support or disprove the validity of facts and/or opinions of an argument by constructing syllogisms or Venn diagrams. See Logic, Anyone? pp. 75-105.

7. Present a list of debatable issues or have students select one of their own. Have students prepare an argument for or against the issue. Conduct a survey of the class before and after the presentation of the argument to determine the effects of the facts, opinions, and values presented.

   Possible issues include:

   - Should motorcyclists be required to wear helmets?
   - Should the elderly be segregated from the rest of society?
   - Should communities allow "adult only" housing?
   - Should a dress code be enforced for students?
   - Should consumers be required to pay a deposit on bottled soft drinks?

RESOURCE MATERIALS:

Harnadek, Anita. Critical Thinking Book I, Chapters 1 and 7.

Harnadek, Anita. Critical Thinking Book II, pp. 2-36.

Lipson, Greta B. and Morrison, Baxter. Fact, Fantasy, and Folklore.

Polette, Nancy. Discovery!, pp. 10-18.

Post, Beverly and Eads, Sandra. Logic, Anyone?, pp. 75-105

"STOP TAKING US FOR FOOLS"

My name is Charlie Simmons. I'm 42 and the father of a 15-year-old girl and a 13-year-old boy. I work as an insurance salesman. I own a nice house on a quiet street in a suburb of New York City. If you want to call me an "average American," it's OK by me. I'm proud of it. I've worked hard to get where I am.

What's my view of the country's energy problems? First, let me tell you what I want and what I think every American deserves. I think every citizen is entitled to a guaranteed supply of energy at the lowest possible price. It's just as important as having a police or fire department or a school for your kids.

Now, as to my idea of what's going on. All right, I know that the price of imported oil has risen by 400% in the last four years. Boy, do I know it! My heating bill was $110 last month. That's more than double what I paid last year, but my salary hasn't gone up that much. Don't get me wrong; I'm willing to pay my fair share. The point is, I get that sinking feeling that I am paying more than my share. I have the feeling I am being taken for a sucker or a fool.

You want an example? Oil company profits in the third quarter of 1977 were the highest they've been in years. That's profits, mind you, not just the gross amount of money taken in. After they paid all of the workers, plus all of the millions of dollars in other expenses, they still made record profits. You don't have to be a math genius to figure out that those oil companies must be charging more for their products than they really need to. As I see it, it's not just the Middle East oil nations that are squeezing money out of us consumers. Our own companies seem to be doing the same.

But whoever is at fault, the consumer is caught in the middle. Energy is like food, clothing, or housing. You can't live without it.

"I'M STUCK!"

But, in one way, energy is very different from other necessities. If I don't like the quality or the price of lamb chops at one store, I can go to another store. If I need a new coat, I can look around for an after-Christmas sale. But what choice do I have when it comes to heating or lighting my home?

"Stop Taking Us For Fools"

The utility company has no competition. And they don't have "bargain sales." So I'm stuck.

You think I'm exaggerating? Well, do you remember one of the things President Carter said about energy? He said that his government was going to see to it that there would be no "excess profits" made as a result of putting a national energy plan into effect. But it looks to me as though that has already begun, even before a national energy plan has gone into effect.

There are already reports from around the country of people getting cheated by fly-by-night insulation salesmen. Every time you turn around you hear the familiar message, "insulate your home, save energy, save money." People are doing that. But what is happening? Shady operators are selling inferior materials. There should be strong federal laws preventing this sort of thing. But, no, once again it is the consumer who gets hit.

Another thing: There seems to be no coordination in this whole energy mess. You look one way and you are told to save energy, you look the other way and you see energy being wasted.

Last winter, for example, we went out to visit my brother and his family in Ohio. Well, it was just about a year ago that they had a horrible energy crisis in Ohio. My niece and nephew were out of school because the schools were closed - no heat. Tom, my brother, was out of work for two weeks because the factory where he works had the same problem.

But you know what you saw on TV and in the newspapers? Ads for gas-guzzling cars, electric carving knives, dishwashers, and loads of other energy-eaters. Okay, I know everything can't be done overnight. But if there is a crisis, let's start acting like there is.

But you haven't heard the last yet, friend. Let me tell you what happened to about eight million of us consumers here in the New York City area.

For years, the electric company here in New York spent piles of money to tell people to use more electricity. You couldn't open a newspaper without seeing an advertisement from the electric company telling you to buy air conditioners, electric heaters, blenders, dishwashers, and dozens of other "conveniences of modern life."

"Stop Taking Us For Fools"

Then, out of the blue, they stop all the ads. They say we've got to save energy. It worked. People did as they were asked. They cut energy use. Guess what happened? The power company said that because people had cut their energy use, bills had gone down. The company wasn't making enough money. So they raised the rates!

I'll tell you what it all boils down to. Consumers will do their part. But there has got to be a pay-off. People will cooperate, but they must know what it is they are going to receive in return for their sacrifices. We are not going to be made fools of.

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Energy - What Can We Do Right Now? Easy Energy Reader (Book Four). Washington, D.C.: U.S. Department of Energy, Office of Consumer Affairs, The Education Programs Division. 1980.

> *They do not understand how that which differs with itself is in agreement; harmony consists of opposing tension, like that of the lyre and the bow.*
> *- Heraclitus*

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CREATIVE THINKING: OVERVIEW

- Creative Thinking: Person, Process, Product
- Teacher Self-Evaluation
- Creativity: A Disciplined Approach
- Creativity Model
    - Tri-Level Model by Treffinger
    - Application of Creative Learning Model
- Creative Reading Checklist
- Fluency
    - Brainstorming
        - . Guidelines
        - . Procedures
        - . Suggested Ideas for Brainstorming
    - OM: Spontaneous Problems
        - . Guidelines
        - . Suggested Spontaneous Problems
- Flexibility
    - Attribute Listing
        - . Procedure
    - Variations of Attribute Listing
        - . "Miss McGilliccuddee"
        - . "Odd Man Out"
        - . Concept Formation
        - . Concept Attainment
        - . Morphological Forced Connections
- Originality
    - Analogous Relationships
        - . Analogy in Critical Thinking
        - . Analogy in Creative Thinking
        - . Synectics
        - . Application

(continued)

- Elaboration
  - SCAMPER
    - SCAMPER Questions
    - Application with Brainstorming and Attribute Listing
    - Content Area Applications
    - Guidelines for Visual Brainstorming
      - Resource Sheet, "Visual Brainstorming"
- Evaluation: Deferred Judgment, Affirmative Judgment, Positive Thinking
  - Strategies for Evaluation
  - Evaluative Thoughts (Famous Quotations)
- Bibliography for Creative Thinking Strategies

CREATIVE THINKING

> *It takes courage to be creative; just as soon as you have a new idea you're in the minority of one.*
> *- E. Paul Torrance*

Creative thinking is a balanced combination of convergent and divergent processes. Divergent thinking requires one to reach beyond predetermined responses and explore a broad spectrum of possibilities; convergent thinking requires one to focus on a single answer or a limited set of possible outcomes. Both types of thinking are integral parts of creativity, and one should not be pursued at the expense of the other. A definition of creativity should not be limited to cognitive processes, however, but should also include an understanding of the affective components of the creative person. Moreover, the creative person must integrate the cognitive and affective domains in order to create products that are unique, that contribute toward the growth of the individual, and that benefit society. A consideration, therefore, of the process, of the person, and of the product must be included in a complete definition of creativity.

CREATIVE PROCESS : The creative process, as illustrated by Treffinger's Creative Learning Model (p. 110), involves a structured hierarchy that ranges from the basic functions of fluency, flexibility, originality, and elaboration toward the development of self-directed learning. Creativity is an ongoing cyclical process which can be taught by providing an enriched content, a nonjudgmental environment, and a strong foundation of questioning and critical thinking skills.

CREATIVE PERSON: Although the creative process can be taught, one needs to consider the emphasis which has been placed on critical thinking in the schools. As a result, the academically talented students may not see themselves as creative persons; they may be reluctant to take risks, to be open to new ideas and experiences, and to be tolerant of ambiguity. The teacher, as a model for risk-taking and independent inquiry, needs to foster a climate in which the learner can feel safe to experiment.

CREATIVE PRODUCT: Products generated in a creative atmosphere can take a variety of forms: written, performed, or constructed. Whatever form they take, the learner should be guided toward productions that are novel, but not trite; that are creative, but disciplined; and that provide opportunities for independent inquiry and self-actualization. Students need to recognize the difference between basic tools, such as brainstorming, and final products which are complex solutions of real problems.

Whenever possible, students should be involved in establishing the criteria by which their products will be evaluated.

TEACHER SELF-EVALUATION
FOR
ENCOURAGING CREATIVE PRODUCTION

___ 1. I provide stimuli for as many of the senses as possible.

___ 2. I guide students to recognize that creativity can be improved by working in a disciplined manner.

___ 3. I verify that students understand the instructional objectives for the creative activities we do.

___ 4. I teach a variety of strategies for overcoming blocks to creativity.

___ 5. I make a conscious effort to provide opportunities for students to be creative, to be original, and to try to think of new ways to solve a problem.

___ 6. I provide a non-threatening atmosphere in which students are encouraged to raise questions.

___ 7. I help students make the transition from convergent tasks to creative production by using warm-up exercises.

___ 8. I instruct students in the principles of brainstorming but incorporate strategies for the evaluation of ideas.

___ 9. I encourage students to develop criteria to judge both the work of their peers and themselves.

___ 10. I encourage students to apply affirmative judgment and to make positive self-statements about their creativity.

___ 11. I help students to defer judgment and to keep an open mind when new ideas are being generated.

___ 12. I attempt to integrate divergent production and evaluation into as many content areas as possible.

___ 13. I help students to recognize and value the components of convergent and divergent thinking in creative productions.

___ 14. I model creative thinking and apply it to the daily curricula whenever possible.

___ 15. I provide opportunities for the students to share their creative products with appropriate audiences.

CREATIVITY: A DISCIPLINED PROCESS

> *Genius is one percent inspiration*
> *and ninety-nine percent perspiration.*
> *- Thomas Alva Edison*

Like critical thinking, creative thinking is a disciplined process which can be improved by employing a variety of strategies. Techniques for creative thinking can be arranged in a hierarchy of complexity as demonstrated by Treffinger's "Model for Encouraging Creative Learning" (1980). The model shows that cognitive and affective abilities are important to creativity, and that convergent and divergent aspects are involved at each level as well. Divergent functions at Level I include activities such as brainstorming and SCAMPER. At Level II, higher order thinking skills are involved in research tasks and other problem solving assignments. The learner defines original problems and independent goals for inquiry and achievement at Level III; ideally, Level III experiences should involve real life challenges. As in the questioning taxonomies, or levels of critical thinking, high creative and independent thinking requires a strong foundation of skills at the basic level. A French maxim makes this point analogically: "He who has imagination without learning has wings and no feet."

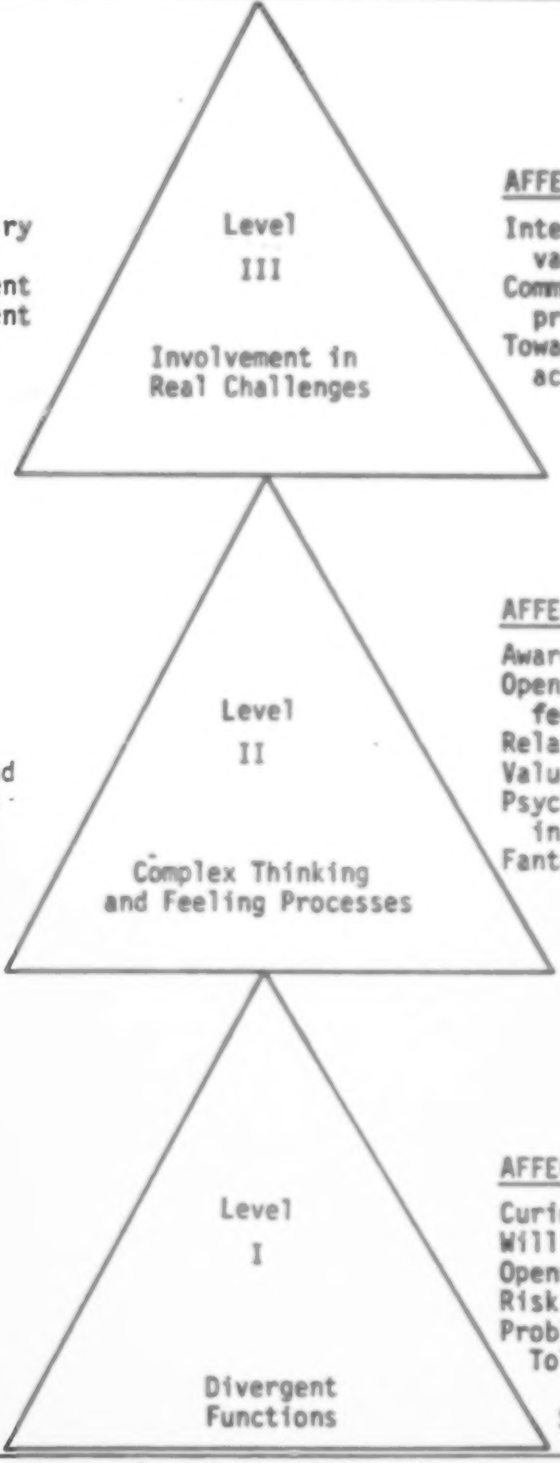
Just as one should not limit thinking to basic knowledge, one should not stop with Level I activities which are designed to stimulate the creative process. Treffinger (1984) cautions that the limitation of creative activities at a basic level is tantamount to the production of "cerebral popcorn" — that is, activities which are enjoyable but meaningless unless they are directed toward a worthwhile goal or seen in relationship to a more complex procedure. Raudsepp (1981) emphasizes, "the creative process does not end with an idea; it starts with an idea" (p. 188).

The research in creativity has shown that the production of many ideas (i.e., fluency), especially those generated at the end of a brainstorming-type session, is likely to yield useful creative ideas. The following examples from Olson's guide, The Art of Creative Thinking (1980), demonstrates the importance of fluency.

> Edison constructed three thousand different ideas in connection with the electric light, each of them reasonable and apparently likely to the good. Yet, in only two cases did his experiments prove the truth of his theory and lead to patents. He once said he would try anything to solve a technical problem, even Limburger cheese (p. 64).
>
> Alfred North Whitehead provided good insight into the value of quantity with these words, "We need to entertain every prospect of novelty, every chance that could result in new combinations, and subject them to the most impartial scrutiny. For the probability is that nine hundred and ninety-nine of them will come to nothing, either because they are worthless in themselves or because we shall not know how to elicit their value; but we had better entertain them all, however skeptically, for the thousandth idea may be the one that will change the world" (p. 65).

Edison's willingness to consider something as farfetched as "Limburger cheese" demonstrates the importance of flexibility in thinking. Characteristics of creativity such as fluency, flexibility, as well as originality, elaboration, and evaluation, are defined and described within this section on creative thinking. Examples show how the strategies of brainstorming, attribute listing, analogous relationships, and SCAMPER can be used to develop the elements of creativity, and also, how these strategies can be applied across the curricula.

A MODEL FOR ENCOURAGING CREATIVE LEARNING*


Level
III
Involvement in
Real Challenges
Level
II
Complex Thinking
and Feeling Processes
Level
I
Divergent
Functions

COGNITIVE

Independent inquiry
Self-direction
Resource management
Product development
"The practicing professional"

AFFECTIVE

Internalization of values
Commitment to productive living
Toward self-actualization

COGNITIVE

Application
Analysis
Synthesis
Evaluation
Methodological and research skills
Transformations
Metaphor and analogy

AFFECTIVE

Awareness development
Open to complex feelings, conflict
Relaxation, growth
Values development
Psychological safety in creating
Fantasy, imagery

COGNITIVE

Fluency
Flexibility
Originality
Elaboration
Cognition and memory

AFFECTIVE

Curiosity
Willingness to respond
Openness to experience
Risk taking
Problem sensitivity
Tolerance for ambiguity
Self-confidence

Printed with permission: *Treffinger, Donald J., Encouraging Creative Learning for the Gifted and Talented. National/State Leadership Training Institute on the Gifted and Talented (N/S-LTI-G/T), Office of the Superintendent of Ventura County Schools, Ventura, California, 1980.

APPLICATION OF CREATIVE LEARNING MODEL

Level III

COGNITIVE

Independent inquiry
Self-direction
Resource management
Product development
"The practicing professional"

The students will use creative problem solving and create a document to govern their classroom.

AFFECTIVE

Internalization of values
Commitment to productive living
Toward self-actualization

Level II

COGNITIVE

Application
Analysis
Synthesis
Evaluation
Methodological and research skills
Transformations
Metaphor and analogy

The students will analyze the society in the Twenty-One Balloons and compare it to the Plymouth Colony.

OR

The students will research other ideal societies and compare them to the Plymouth Colony.

AFFECTIVE

Awareness development
Open to complex feelings, conflict
Relaxation, growth
Values development
Psychological safety in creating
Fantasy, imagery

Level I

COGNITIVE

Fluency
Flexibility
Originality
Elaboration
Cognition and memory

The students will brainstorm a variety of rules and laws they think would be necessary for an ideal society.

AFFECTIVE

Curiosity
Willingness to respond
Openness to experience
Risk taking
Problem sensitivity
Tolerance for ambiguity
Self-confidence

This application of the CREATIVE LEARNING MODEL can be used to direct students through the three levels once they have studied the Mayflower Compact and acquired an understanding of a contractual agreement.

Resource Sheet 9

CREATIVE READING CHECKLIST

NAME ______________________________ PERIOD ______________________________

DATE ______________________________ GRADE ______________________________

____ is able to:
(student's name)

		Seldom				Often	
1.	Express feelings or emotions about things read.	1	2	3	4	5	NA
2.	Apply information read to different settings.	1	2	3	4	5	NA
3.	Make guesses about what will happen next.	1	2	3	4	5	NA
4.	Think of other ways the story could have ended.	1	2	3	4	5	NA
5.	Question why characters behave certain ways.	1	2	3	4	5	NA
6.	Add my own ideas to the author's ideas.	1	2	3	4	5	NA
7.	Compare author's conclusion with other possible conclusions.	1	2	3	4	5	NA
8.	Relate what is read to my own experience.	1	2	3	4	5	NA
9.	Visualize what I read.	1	2	3	4	5	NA
10.	Express how I might have changed the story.	1	2	3	4	5	NA
11.	See questions left unanswered by the author.	1	2	3	4	5	NA
12.	Ask questions that demonstrate insights about things which are read.	1	2	3	4	5	NA
13.	Give examples when reading about something.	1	2	3	4	5	NA
14.	Organize information obtained while reading to show relationships between things.	1	2	3	4	5	NA
15.	Discuss what I have read as if it has really happened.	1	2	3	4	5	NA
16.	Use what is read to solve problems.	1	2	3	4	5	NA
17.	Use what is read as a springboard to original ideas.	1	2	3	4	5	NA
18.	Relate what is read to other things that I have read.	1	2	3	4	5	NA
19.	Question why the author did certain things.	1	2	3	4	5	NA
20.	Express what I would have done in a character's place.	1	2	3	4	5	NA

The reading checklist can be used periodically by students to evaluate their attitudes toward reading. Teachers may use the checklist to monitor reading behaviors of students, as a diagnostic tool, or to generate objectives for creative learning activities.

Reprinted with permission: Martin, Charles E. and Bonnie Crammond, "A Checklist for Assessing and Developing Creative Reading." G/C/T, April 1984, pp. 23-24.

FLUENCY

> *No idea is so outlandish that it should not be considered with a searching, but at the same time, steady eye.* - *Winston Churchill*

Fluency may be defined as the ability to produce many ideas or possible solutions to a given situation. The emphasis is on quantity rather than quality. The ability to generate many ideas provides more options from which to select. A large quantity of ideas increases the probability of producing original ideas or solutions.

The Divergent Questioning Model (p. 29) uses the "quantity" question as a way to elicit fluent responses. Brainstorming is a strategy that provides a structured approach to fluency.

BRAINSTORMING

Brainstorming is designed to generate many ideas and works best in small groups of about three to five participants. It is a strategy that can be used at all phases of problem-solving, but it should not be considered as an end in itself. In the classroom brainstorming may also be used for:

- Warm-ups
- Motivators
- Establishing an accepting climate
- Student-student interaction
- Ice-breakers
- Building confidence
- Reducing fear of risk-taking.

Frequently, ordinary responses will be generated in the beginning. Allow enough time in a session to exhaust common responses. This will force the participants to become more inventive. Repeated applications of brainstorming to appropriate situations will increase the fluency of students.

Brainstorming Guidelines

- No negative criticism.

  Defer judgment until a large number of alternatives has been produced.
- Freewheeling is desired.

  Wild, off-beat, unusual ideas are encouraged.
- Quantity is stressed.

  Include the small, obvious alternatives as well as the wild, unusual, clever ones.
- Combine alternatives.

  Hitchhike or piggy-back on ideas to produce new ones.

Suggested Brainstorming Procedures

1. Explain the guidelines for brainstorming.
   - Assign students to small groups.
   - Designate a recorder for each group. Record all ideas.
   - Set a time limit.
   - Set expectations for a minimum number of responses.
2. Present the problem.
3. Circulate among groups as they work.
   - Encourage spontaneity.
   - Stress a continuous flow of ideas.
   - Offer suggestions for overcoming mind set.
4. Structure a way for students to share ideas.

   EXAMPLE A: Teacher-Directed Approach
   - Have all students come back together.
   - List all ideas on the board.
   - Consolidate and categorize ideas.
   - Evaluate and discard common or inappropriate responses.

   EXAMPLE B: Student-Centered Approach
   - Have the students remain in their groups.
   - Establish criteria for nominating the best ideas in each group.
   - Allow about one minute for selection of three ideas.
   - Provide another minute for identifying the best idea of the three.
   - Have each small group share their three nominations with the total group.
     - Have all the groups vote for the best idea.
     - Compare the large group's selection of the best idea with the choice of the nominating group.
     - Discuss consensus and/or differences in the results.
   - Analyze and evaluate the final results as a total group.
5. Select, plan, and implement the best idea.

Application Ideas for Brainstorming

- Create ways to present information instead of doing a report.
- Design objects that are formed by combining a cube and sphere.
- Think of ways we can conserve energy in our home or school.
- What assumptions could be made about a civilization if a soda can was its only remaining artifact?
- Think of ways to help someone to stop smoking.
- What changes would occur in our society if dinosaurs still existed?
- Think of ways to decrease the noises in the cafeteria.
- Make predictions about the outcome of a story.

OM: Spontaneous Problems

The goal of spontaneous problems in the OM - Creative Competitions procedure is to generate as many creative responses as possible within a given time limit. Emphasis is placed on team motivation, competition to improve the number of creative responses within a team, as well as competition between teams. This procedure should be used after a group has become familiar with basic brainstorming guidelines.

1. Organize students into teams with four to six members each.
2. Have one team respond to a problem while the other teams observe and serve as judges or recorders.
3. Explain the rules:
    - Time limits include one minute to think and a set number of minutes to respond (about two to five minutes).
    - Team members respond in sequence.
    - If one member of the team is stuck, the entire team is stuck.
    - A member may not repeat a response.
    - Each response earns one point;
      creative responses earn three points.
4. Have students analyze the quality of the responses so that the team can increase its capacity for creative responses. Responses may be written or recorded.

Suggested Spontaneous Problems

- Improvise uses for one or two halves of a tennis ball.
- If you were Odysseus, what would you have said the first time you saw Cyclops?
- Name as many meanings for the word run as you can.
- Give as many relevant captions as you can for the situation in the picture.

FLEXIBILITY

> *A man's mind stretched by a new idea can never go back to its original dimensions.*
> *- Oliver Wendell Holmes*

Flexibility involves the willingness to stretch ideas, to change direction, and to alter given information. A person becomes a more flexible thinker by producing many different categories or responses, by using a variety of approaches or strategies in solving a problem, or by analyzing ideas from a different angle or viewpoint.

The viewpoint and supposition questions in the Divergent Questioning Model are an aid for flexible thinking. Another way to develop flexible thinking is through the strategy of attribute listing.

ATTRIBUTE LISTING

Attribute listing shoud be taught after students have learned the techniques of brainstorming. Attributes may be defined as the qualities, characteristics, factors, features, traits, or structural and functional properties of an object, person, or situation. Mind set, premature judgment, conventional and sterotypic thinking can be overcome by implementing this strategy. In the process of attribute listing, students examine and record the feature of an idea or situation in order to redirect their thinking. An analysis of attributes allows students to identify new relationships that will aid problem solving.

Attribute Listing Procedure

1. Develop an understanding of attributes with the students.
2. Begin with a list of responses from a brainstorming session.
   - What changes would provide Professor Sherman with more comfortable balloon travel in The Twenty-One Balloons?
   - Possible responses:
     - Design a gondola that can float.
     - Enclose the gondola to protect from bad weather.
     - Design a more efficient valve to control descent.
     - Modify the ballast for dual-purposes such as for furniture or padding.
     - Identify high energy food for travel.
     - Add a motor to create a dirigible.

3. Have students select an idea that could be improved upon, such as "Design a gondola that can float."

   . Guide the students to identify a focal point such as "gondola" in the main idea and identify its attributes.

   . Possible responses:

     - Size
     - Weight
     - Material
     - Bouyancy
     - Weather-proof
     - Durability
     - Texture
     - Flexibility
     - Shape
     - Portability
     - Maneuverability.

4. Have characters analyze the list of attributes and select those characteristics that could be modified to create the most comfortable floating gondola.

   . Possible response:

   Design a motorized, waterproof gondola made of fiberglass which could float or travel on the bottom of the sea.

Variations of Attribute Listing

Variations of attribute listing include "McGilliccuddee Mania " (p. 56) and "Odd Man Out." In these exercises, the student is required to identify the attribute rule which determines whether items are included or excluded from a category of given terms.

. Odd Man Out Example:

Directions: Which term does not belong:

- Dog, camel, whale, mackerel, elephant
  (Answer: mackerel - all the others are mammals.)
- Chicago, Baltimore, Boston, Hawaii, San Francisco
  (Answer: Hawaii - all the others are cities.)

Concept formation is a variation of attribute listing used to make connections among elements of a concept. Students are given a list (or brainstorm a list) of terms or ideas about a topic, question, or problem, and then arrange the terms in attribute clusters. Visual techniques such as mapping, branching, webbing, linking, or Venn diagrams may be used to organize the terms into groups which can then be labeled. Students should be encouraged to create different ways to regroup using new or unusual relationships.

This strategy is also effective for setting criteria, outlining, and locating the main idea.

In the following example, the students must organize a selected list of terms according to the attributes of a target word COAL.

- Concept Formation Example:

Directions: Classify the words in a list into at least three attribute groups. Develop as many attribute groups as possible. Each word will be used at least once. Each attribute group should contain at least three words.

TARGET WORD: COAL

tar
silver
log
ink
raven
iron
kerosene
gasoline
copper

ANSWER:

ATTRIBUTE	TERMS
Use as a fuel	Kerosene, gasoline, log
Blackness	Tar, ink, raven
Mineral	Silver, copper, iron

Concept attainment is similar to the Miss McGilliccuddee technique in that students are required to discover the attribute rule of a concept. In the strategy of concept attainment, positive and negative examples of a concept are presented. Students identify the concept according to the attribute rule and create examples which demonstrate the rule.

- Concept Attainment Example:

Directions: Try to find out what an IKSORD is.

This is an IKSORD. ⇨ D
This is not an IKSORD. ⇨ S
This is an IKSORD. ⇨ B
This is not an IKSORD. ⇨ K
a) Is this an IKSORD? ⇨ X ________
b) Is this an IKSORD? ⇨ R ________
C) Is this an IKSORD? ⇨ Q ________

(Answers: a)no, b) yes, c) yes; An IKSORD is a figure with at least one closed curve and one line.)

Morphological Forced Connections is a variation of attributes designed to promote inventive thinking through forced associations. Students list the attributes of a concept or problem and brainstorm as many alternatives for the attribute as they can. They then select alternate attributes randomly from the chart to create new forms of the original subject.

. Morphological Forced Connection Example:

Directions: Improve a bath tub.

Attributes:	porcelain	rectangular	water filled	faucets
Alternates:	[✓ glass]	round	[✓ perfume]	hose
	metal	square	milk	sprinkler
	brick	oval	baby oil	[✓ spray]
	cobblestone	[✓ heart-shaped]	powder	irrigation device
	mosaic	figure-eight	sandpaper	buckets

Invention: A glass, heart-shaped tub with a perfume spray.

Application: Develop an ad campaign and use at least two propaganda techniques to convince people to buy the new product.

THE TWO FROGS

Once upon a time, two frogs fell into a bucket of cream.

The first frog, seeing that there was no way to get any footing in the white liquid, accepted his fate and drowned.

The second frog didn't like that approach. He started thrashing around in the cream and doing whatever he could to stay afloat. After a while, all of his churning turned the cream into butter, and he was able to hop out.

MORAL: If you think you can find the second right answer, you are more likely to do so.

- Roger Von Oech

ORIGINALITY

> *A first-rate soup is more creative than a second-rate painting. - Abraham Maslow*

Originality may be defined as the ability to produce clever, novel, and unusual responses. It involves the willingness to take risks, to be unconventional, and to deviate from common patterns. Decision making also plays an integral part in the ability to identify and evaluate ideas as original. Traditionally, original ideas are characterized as being statistically infrequent; however, one needs to recognize that an idea may be unique simply because it is new to an individual's background of experience and that it involves a mental leap for that person. Sometimes individuals can make mental leaps intuitively, but more often, original thinking is the result of a disciplined approach. The original thinker is able to analyze known information, to manipulate and transform it so that new and different relationships are discovered, and finally, to recognize and decide which ideas are the most original. Therefore, the original thinker uses divergent strategies to create ideas and convergent thinking to evaluate and refine ideas into a desirable outcome.

ANALOGOUS RELATIONSHIPS

An analogy is an inferred relationship of similarity between objects or situations that may appear to be dissimilar. Identifying the common attributes that characterize the analogous bond allows one to infer new relationships. The applications for analogous relationships are different for critical thinking and for creative thinking:

- Critical Thinking Analogy is used to show parallelism as in support for argumentation, for example A : B :: C : D.
- Creative Thinking Analogy is used to perceive new relationships so information can be restructured. In problem solving this strategy allows one to reconstruct the elements of a problem and, thus, overcome premature judgment.

Students need to have an understanding of the literal analogy as traditionally used in critical thinking before applying the concept to figurative analogies in creative thinking. An understanding of the analysis of attributes is also helpful. Analogous relationships provide a strategy for developing originality but should not be considered as an end in themselves; according to de Bono (1970):

> An analogy is a convenient way of getting moving, for analogies have a definite 'life' of their own. There is no attempt to use analogies to prove anything. They are only used as stimulation. The main usefulness of analogies is as vehicles for functions, processes, and relationships, which can then be transferred to the problem under consideration to help restructure it (p. 174).

Analogy in Critical Thinking

The basic components of analogy in critical thinking are clearly described by Patricia A. Alexander in her article, "Training Analogical Reasoning Skills in the Gifted" (Roeper Review, April 1984).

- ENCODING

  The attribute identification component; the representation of identifiable characteristics of each term in the analogy. The term, ball, for example, could be described by such attributes as round or bouncy.

- INFERRING

  The determination of a rule that relates adjacent terms. In the analogy, feather : bird :: leaf : tree, the relationship between feather and bird is that feather is part of a bird (feather grows on bird).

- MAPPING

  The discovery of relationships between non-adjacent terms. In the analogy, king : prince :: queen : princess, king and queen are both members of royalty differentiated on the basis of gender.

- APPLYING

  The completion of the analogy; the utilization of derived rules to generate the predicted response term. In the analogy, bat : ball :: hammer : ______________________, the best answer would be nail since bat is used to hit a ball and a hammer is used to hit a nail.

> *Now strange words simply puzzle us; ordinary words convey only what we know already; it is from metaphor that we can best get hold of something fresh.*
>
> *-Aristotle*

Analogy in Creative Thinking

Analogy in creative thinking may be used to enhance the brainstorming strategies of problem solving and creative production. The responses generated by brainstorming trigger associations which allow the student to restructure the ideas of the problem. Through the application of forced association questions, involvement questions, and mental imagery, students are directed to formulate ideas and questions into metaphors and similes. The figurative expressions permit one to perceive the problem in a novel way or to generate original outcomes.

A model for teaching the transformation of metaphors and similes into analogous relationships is presented as "Semantics Sample II" (p. 49). The creative application of analogy is made at the idea-finding stage of the Creative Problem Solving Model (p. 164) and also forms the basis for the synectics approach to creative learning.

Synectics

Synectic strategies which evolved from the work of J.J. Gordon and his associates are explained by Treffinger in *Encouraging Creative Learning for the Gifted and Talented: A Handbook of Methods and Techniques* (1980).

> Synectics is a term derived from Greek, which means the joining together of different and apparently irrelevant elements. Applied to creative learning, synectics involves the use of metaphor and analogy to develop original ideas and new combinations of ideas . . . . The two basic principles in synectics involve *making the strange familiar and making the familiar strange* . . . (p. 65).

Synectics uses analogy as a disciplined technique that encourages the suspension of judgment and allows the problem solver to develop new perspectives. Metaphors and similes are developed through the use of four basic analogical categories. The analogical forms selected may be determined by the problem under consideration. In the following chart, "Application of Analogous Relationships," four types of figural analogies have been used to solve the problem, "Unleashed dogs are running wild."

APPLICATION OF ANALOGOUS RELATIONSHIPS

PROBLEM STATEMENT: Unleashed dogs are running wild.

Type of Analogy	Explanation	Analogical Question	Possible Response	*Response Level
PERSONAL	The problem-solver identifies personally with the problem and its solution.	How would I feel if I were a dog?	I'd bark, have four paws, and wag my tail.	Factual *(L)*
			I'd jump on people and try to make friends.	Inferential *(CR*
			I'd wish I could be wild and free.	Complex/ Empathetic *(CV*
DIRECT	A traditional use of analogy for comparison of parallel information.	How is an unleashed dog like an escaped convict?	They are both running away.	Factual *(L)*
			They are both breaking the law.	Inferential *(CR*
			They are both in search of freedom.	Complex/ Abstract *(CV*
SYMBOLIC	Similar to personal analogy but compares attributes of the problem with impersonal objects or images.	How is an unleashed dog running wild like a volcano?	Both are unable to be controlled.	Factual *(L)*
			Both may remain safe for a time but suddenly become violent.	Inferential *(CR)*
			Both are in conflict - one is in conflict with society; one is in conflict with nature.	Complex/ Abstract *(CV)*
FANTASY	The problem-solver can use magic or fantasy to solve the problem.	How is an unleashed dog like the Sorcerer's Apprentice?	The dog could cast a spell on dog-catchers so they change into cats.	Factual *(L)*
			The dog has new freedom, but does not know how to use it wisely so that the "cats" in the preceding example quickly get out of hand.	Inferential *(CR)*
			The dogs could form a company to go on the Quest for the Golden Leash--an invisible talisman which empowers humans to understand animal language. Thus, communication provides the ultimate freedom.	Complex/ Abstract *(CV)*

* L, Literal; CR, Critical; CV, Creative. See "A Comparison of Taxonomies" for explanations of levels.

Application of Analogous Relationships

From the chart one can see the different types and levels of responses for each category of analogy. Students should be encouraged to produce original analogies or metaphors as they react to the problem.

The final response for the fantasy analogy sounds highly creative and imaginative, but it could trigger practical solutions.

- What are some ways in which dogs might communicate with people?

Possible Responses: Body Language
Dog psychologists
Dr. Doolittle
Animal trainers.

- How could an animal trainer help dogs to communicate with people?

Possible Responses: Dogs could be trained as though they were on a Golden Leash; thus, in the master's absence, the animal would always obey the last command, such as "sit," "stay," and even, "stay at home."

An electronic computerized device could be implanted on the animal which could be programmed with a variety of commands.

- How could this idea of the Golden Leash be completed to solve the original problem: Unleashed dogs are running wild.

Possible Response: Just as drivers with too many points have to be re-educated, dogs which run away have to go to school with their masters to learn the Golden Leash.

Students should recognize that this may be a long-range solution and does not take care of the immediate problem. They may need to find out whether solutions can be carried out with existing knowledge and technology. For example, a review of laws and ordinances in the community may suggest the need for revisions or new laws. As a result of developing analogous relationships, it is possible for students to identify real-life problems.

Students who have difficulty formulating the appropriate questions or responses may need to review levels of questioning and/or attribute listing in order to move from the production of many factual responses toward ideas that are complex and original.

The use of analogous relationships should be emphasized as a strategy to refine the quality of original ideas rather than the quantity. As with other brainstorming techniques, the use of figural analogies is a strategy for overcoming obstacles to creativity — it is not an end in itself.

Once students understand the purpose for figural analogies, they can use the strategy to generate analogical questions or responses appropriate for writing activities:

. Poetry

. Creative narratives

. Comparisons

. Opinions.

Analogous relationships may also be used to:

. Develop inventiveness

. Explore self-awareness and personal growth

. Broaden perspectives

. Develop generalizations

. Provide clarification

. Enrich mental imagery and visualization

. Expand vocabulary

. Analyze humor

. Establish a model

. Transform information to overcome mind set

. Restructure a problem or situation

. Appreciate complexity of figurative language.

ELABORATION

Anything one can imagine,
others can make real.- Jules Verne

Elaboration is the ability to expand, develop, and embellish ideas and products. It involves recognition of original ideas and the willingness to go beyond the initial creative insight. The elaborative thinker must be willing to risk the evaluation of original works, ideas may be rejected, or ideas may require additional energies and effort. Ideas which require elaboration must be closely scrutinized for the interrelationship of component parts, for the complexity of detail, and for the integrity of the product or outcome as a whole. This procedure necessitates the simultaneous processing of these components so that a harmonious balance of analysis and synthesis is maintained.

Elaboration products are characterized by a richness of style, clarity, organization, and sensory appeal. Evaluative criteria for creative productions involves deferred judgment, which allows the production of original ideas, and affirmative judgment, which allows one to refine and elaborate in a positive manner. Torrance (1979) stresses that elaboration is essential to creative production. In order for the creative product to have value, it should transform insight into reality ; it should transform a creative idea into a form which can be communicated. He also emphasizes that elaboration goes beyond organization and involves "stimultaneous processing"(p. 68). Finally, he reminds us that elaboration may serve as the vehicle for overcoming resistance to the acceptance of innovative ideas.

Viewpoint and supposition questions in the Divergent Questioning Model facilitate elaboration. Attribute listing and analogous relationships also stimulate elaborative production. Another strategy is the SCAMPER technique developed by Robert F. Eberle (1977).

SCAMPER

SCAMPER, an acronym for an extensive checklist of questions, can be used to elaborate responses during brainstorming, phases of problem solving, and creative production. Each letter in SCAMPER represents a key word for elaborating an object or situation. SCAMPER can be implemented in much the same way as the procedure for attribute listing. Like other brainstorming procedures, SCAMPER is a strategy for overcoming mind set and for expanding ideas. It is possible to use the checklist items selecting to meet a specific purpose. By developing creative imagination through visualization processes, SCAMPER provides a disciplined approach for elaborating original ideas or products.

SCAMPER

S - Substitute - to have a person or thing act or serve in the place of another.

- What can be substituted?
- Who else?
- What other process?

C - Combine - to bring together, to unite.

- What can be combined with it?
- What about a blend, an alloy, an assortment, or ensemble?
- Can ideas be combined?

A - Adapt - to adjust for the purpose of suiting a condition or purpose.

- What else is like this?
- What other ideas does it suggest?

M - Modify - to alter the form.

- What can be changed?
- Is it possible to change the meaning? sound? color? odor? form? shape? motion?

- Magnify - to enlarge or to make greater in form or quality.

- Is it possible to add more time or greater frequency?
- Is it possible to make it stronger? higher? longer?
- Can it be duplicated? multiplied? exaggerated?

- Minify - to make smaller, lighter, slower.

- Is it possible to shorten time or decrease frequency?
- Is it possible to make it weaker? lower? shorter?
- Can it be divided? shrunk? condensed? compressed?

P - Put to other uses - to be used for purposes other than originally intended.

- Is it possible to use it in new ways as it is?
- Can it be put to other uses if it is modified?
- Are there other places where it can be used?
- Can another population be reached?

E - Eliminate - to remove, omit, or get rid of part of a whole.

- What can be eliminated? subtracted? simplified?

R - Rearrange - to change order or adjust.

- Is it possible to interchange the components? sequence? cause and effect?
- Can it be reversed? inverted? transposed? turned?

Reprinted with permission: Eberle, Bob. SCAMPER: Games for Imagination Development. Buffalo, N.Y.: D.O.K. Publishers, 1971.

110

Application of SCAMPER as an Elaboration Technique

Objective: Generate ideas for an imaginative narrative.

1. Students brainstorm a verbal or written list of names or uses for a roll of tape as a motivation for the Pre-Writing Phase in the Three-Phase Approach to Writing.

Brainstorm Listing for a Roll of Masking Tape

- ring
- circus ring
- bracelet
- pinkie ring for a giant
- ring toss
- coaster
- wheel
- steering wheel
- hula hoop
- halo
- tire
- inner tube
- monacle
- bicycle rim
- washer
- doughnut

2. Students have focused on only one attribute -- roundness -- for the roll of tape. The attribute listing procedure (p.118) helps students to perceive other qualities of the item.

Attribute Listing for a Roll of Masking Tape

- roundness
- shape
- color
- layered
- sticky
- can be pulled apart
- can be torn
- length
- can be twisted
- flexible
- not waterproof
- washable
- rollable
- cylindrical
- size
- portable

3. Students may choose one or more of the attributes upon which to elaborate using SCAMPER. In the following example, the attribute of length has been "Scampered."

SCAMPER Listing for a Roll of Masking Tape

Acronym	Key Words	Responses
S	Substitute	. clothesline . fishing line
C	Combine	. spring . grill
A	Adapt	. wallpaper . yo-yo
	Modify	. tunnel . form letters
M	Minify	. dress trim . string
	Magnify	. highway . conveyor belt
P	Put to Other Uses	. mummy costume . fly paper
E	Eliminate	. sliding board . measuring tape
R	Reverse (unwind)	. toilet paper . ticker tape
	Rearrange (coiled inside)	. plate . funnel

4. **Students are directed to imagine that they have been marooned on a deserted island with a case of masking tape rolls and to describe, in an imaginative narrative, ten uses for the tape rolls that would help them to survive.**

Content Area Applications

1. Language Arts

   - Use scampered ideas to develop imagery and figurative language in poetry. Ideas can also be used to create shape poems or other poetic forms.

   - Ideas can be used to motivate topics for compositions such as writing a play, an imaginative narrative, an ad campaign, an explanation of values, or a set of directions.

   - In reading, the list of ideas can be classified into various categories and labeled to show the main idea or generalization.

2. Social Studies

   - Use the listing to develop independent project ideas.

   - Stimulate discussions about innovative solutions to social problems such as:

     In what ways could masking tape be used to improve your lifestyle?

     In what ways could masking tape have been used to improve conditions aboard the *Mayflower*?

3. Science

   - Select ideas from the listing to demonstrate the scientific method of testing a new use for a product.

   - In an ecology unit discuss ways in which masking tape, for example, can be used to promote conservation.

Guidelines for Visual Brainstorming: From Visual Thinking by Bob Eberle

1. Maintain a quiet environment free from distracting noises or interruptions.
2. Physically relax, and mentally guide attention to the brainstorming topic.
3. Encourage images to stream into the conscious mind; accept all without value judgments.
4. Be aware of and capture faint images that may be drifting by.
5. Be alert to signs and symbols that may appear without apparent meaning and value their potential.
6. At will, manipulate images to achieve a desired outcome.
7. Record ideas and images for evaluation and processing.

When applied by individuals, visual brainstorming is a highly productive method of producing ideas and images. Visual thinking may be willfully guided toward a particular aspect of a problem, challenge, or opportunity. Mental pictures lend themselves to manipulation. They may be placed in motion, viewed in color, and seen in three dimensions. Visual images are multi-sensory; they elicit sound, textures, odor, and taste. Visual thinkers have control over their images. They are able to move their visions toward desired goals. They do not allow their flights of fancy to be shot down by self-imposed negative criticism. Visual thinkers write their own scripts and bring players on stage to perform their roles with meaning and understanding.

Here is an example of visual brainstorming. An inventor friend, with well over one hundred patents to his credit, describes his way of visualizing. "I consider all of the operations associated with the machine I am going to build. That will include mechanics, electrics, hydraulics, pneumatics, and many more of those kinds of things. Now for each of these operations, there are many possible approaches that I will want to consider. So, right in front of me, in my line of sight, I place a slot machine with more than the usual three wheels. Each of the wheels will represent one of the operations that go into building this machine. On the wheel for mechanics, I will plaster all of the mechanical operations that I may care to use. I do the same with the wheel for electric, and so on. When I have all of the wheels plastered with ideas, I pull the handle and look at the combinations that come up. When the right combination comes up, I know that I have hit the jackpot. From that point on, its a simple matter of building the machine. There it is right in front of me . . . the machine is functioning . . . it is doing what it is supposed to do."

Highly skilled visualizers may evoke holistic images. Whatever the challenge may be; when the visual response is received, "it is all there.." The image may reveal a story plot, musical score, completed work of art, or an invention that meets the requirement of its intended function. Visions may also appear as symbols having complex meanings. If visual brainstorming seems to be overwhelming; remember, its purpose is the same as traditional brainstorming . . . that of producing ideas. Much the same as other learned skills, visual brainstorming improves with practice.

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New York: D.O.K. Publishers, Inc., 1982.

VISUAL BRAINSTORMING

S	SUBSTITUTE	To have a person or thing act or serve in the place of another.
C	COMBINE	To bring together; to unite.
A	ADAPT	To adjust for the purpose of suiting a condition or purpose.
M	MODIFY MAGNIFY MINIFY	To alter, to change the form. To enlarge, to make greater in form or quality. To make smaller, lighter, slower.
P	PUT TO OTHER USES	To be used for purposes other than originally intended.
E	ELIMINATE	To remove, omit, or get rid of a quality, part or whole.
R	REVERSE REARRANGE	To place opposite or contrary, to turn it around. To change order or adjust.

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Scamper Games for Imagination Developmentment,
Buffalo, New York: D.O.K. Publishers, Inc., 1977.

Resource Sheet 19

EVALUATION

> *A man cannot speak, but he judges himself.*
> *... no man thoroughly understands a truth*
> *until he has contended against it. - Emerson*

Evaluation is the process of judging, measuring, or assessing the value of ideas, processes, or products. The success of fluency, flexibility, originality, and elaboration strategies depend upon effective evaluation. A questioning attitude and critical thinking are essential.

Evaluation is the keystone of creativity, for the inability to recognize and value an original idea may result in lost opportunities. The interplay of deferred judgment and affirmative judgment (Treffinger 1984) facilitates the creative process.

Deferred judgment is the withholding of any evaluative comments, positive or negative, during discussions, creative production, or problem solving. Withholding judgment is especially important during idea-generating activities such as brainstorming. Inherent in the definition is the understanding that judgment is delayed but not eliminated.

Affirmative judgment is the willingness to consider all ideas with a positive attitude, and it is also the recognition that even a good idea can be made better. This type of judgment is most effective for selecting criteria, making decisions, and evaluating solutions and products.

Positive thinking is the process of maintaining a balanced, optimistic approach to problems and toward life in general. The key word is balanced because being positive and affirmative means identifying the pluses as well as the minuses of a situation. Therefore, judgment is not unconditional but rather seeks to identify the conditions by which negative attributes of a problem can be minimized or eliminated. Olson (1980) cautions that positive thinking can become an enemy if it causes one to accept conditions which need to be improved (p. 180).

A mistaken notion in creative production is that being open and positive disallows the use of criticism. A positive thinker is a strong critical thinker who can recognize the validity of a criticism and determine whether or not it should be considered. A positive thinker recognizes that judgment cannot be unconditional and that deferred judgment and affirmative judgment are evaluative strategies which will identify potential growth in the seed of an idea.

Evaluation . . . the last step . . . the first step . . .

Evaluation is a never-ending, ongoing process which should occur at every level of critical and creative thinking and at every phase of problem-solving.

Frequently, evaluation becomes the "forgotten step" because students assume that once something is said, written, or constructed, it is over — until the teacher gives a grade. Therefore, they may resist self-evaluation and the process of refining work.

Whenever possible, academically talented students should have the opportunity to design personal learning objectives and to establish the criteria by which their work will be evaluated. Students may need guidance in setting realistic goals. They may also lack the prerequisite knowledge or skills for completing a proposed project in a manner commensurate with their ability. Therefore, they may require direct teaching of ways to organize, practice, and present highly original ideas.

The following evaluative suggestions are designed to help students value their efforts so that their work accurately reflects ability.

Strategies for Evaluation

HAVE THE STUDENTS . . .

1. Use the question starter from Creative Problem Solving (CPS) to improve a project.(p. 154).

   - In what ways might we/I . . . (IWWMWI...).

2. Brainstorm attributes of a problem solution and rank order them. In what ways do they meet the original purpose of the problem goal?

3. Prepare an evaluation matrix as described in Step 4, "Solution-finding of CPS (p.169).

4. Combine the 5 W's and 1 H (who, what where, when, why, and how) questions with SCAMPER (p.120).

5. Pretend to sell the idea or product, and develop an ad campaign to overcome all criticism. Make sure the ads satisfy the "truth in advertising" laws.

6. Develop and use checklists such as those used in each section of this guide. Design items to assess content information, processing skills, and personal attitudes.

7. Use a Think-Pair-Share strategy to evaluate one another's products.

8. Design a contract agreement or a proposal for projects.

9. Analyze a project proposal or outcome to see where it would occur in Bloom's taxonomy. Revise the project, if necessary, so that it happens at the highest levels.

10. Use metacognition to analyze the reasons for using particular materials, resources, and processes. Record all excuses and obstacles and brainstorm ways to overcome them.

11. Use the "What if . . ." strategy from the Divergent Questioning Model.

    - What if . . . the principal were coming to see the presentation? Should anything be changed?
    - What if . . . the project breaks, falls apart, gets rained on, melts, etc.? In what ways will I still be able to demonstrate my ideas?

12. List potential solutions or attributes of a problem in plus or minus columns. Select the strongest plus and SCAMPER it; select the strongest negative and modify it enough to be at least a weak positive.

13. Imagine seeing the completed product through the eyes of an enemy. List the comments that result. Rank order the comments from strongly agree to strongly disagree.

14. Rehearse a presentation or a problem explanation with someone who has not been involved with the project and who can be objective. Have the person repeat the explanation and listen for gaps of knowledge or misunderstandings.

15. Tape record a proposed presentation or a problem explanation. Pretend to hear it for the first time and listen critically.

16. Have a fellow student serve as a coach and provide constructive feedback based on personal objectives.

17. Visualize the worst possible outcome for the product, and prepare a plan to counteract the disaster.

18. Visualize the most ideal outcome and note the qualities which guarantee success. Implement the five best qualities to whatever degree is possible.

19. Make two positive statements about an outcome before introducing a negative comment.

20. Use Mamie Porter's non-threatening approach to evaluation which is described in Negative Criticism by Sid Simon.

    - What do I like about what I did?
    - What would I change if I could?
    - Do I need help from the teacher (or anyone else)?

> *A pearl diver goes out in his boat to the oyster beds, takes off his clothes, dons his swim suit and helmet, tosses a bag over his shoulder, and dives into the water. He very efficiently collects oysters and, when the bed is exhausted, he surfaces, goes ashore, and opens each one.*
>
> *- Eugene Von Fange*

Evaluative Thoughts Worth Thinking About . . .

- Remember obstacles either 'polish us up' or 'wear us down.' A diamond was once just a hunk of coal until it was put under pressure, then polished to perfection. - Mary Kay Ash

- He that wrestles with us strengthens our nerves and sharpens our skill. Our antagonist is our helper. - Edmund Burke

- Sometimes we look for one thing and find another. - Cervantes

- Be not afraid of going forward slowly, be afraid only of standing still. - Chinese Proverb

- Small opportunities are often the beginning of great enterprises. - Demosthenes

- Far better never to think of investigating truth at all than to do so without a method. - Descartes

- You may not realize it when it happens, but a kick in the teeth may be the best thing in the world for you. - Walt Disney

- Our greatest weakness lies in giving up. The most certain way to succeed is always to try just one more time. - Thomas Edison

- I have no interest in spilt milk. - Thomas Edison

- Everything should be made as simple as possible, but not simpler. - Albert Einstein

- Nothing great was ever achieved without enthusiasm. - Emerson

- There is nothing more fearful than creativity without taste. - Goethe

- First a new theory is attacked as absurd; then it is admitted to be true, but obvious and significant; finally it is seen to be so important that its adversaries claim they themselves discovered it. - William James

- Mishaps are like knives, that either serve us or cut us, as we grasp them by the blade or the handle - James Russell Lowell

- When the only tool you have is a hammer, you tend to treat everything as if it were a nail. - Abraham Maslow

. Habit is an iron path, and you know yourself how much my Wolfgang has still to learn. - Leopold Mozart

. Every goal man reaches provides a new starting point, and the sum of all man's days is just a beginning. -- Lewis Mumford

. If I have seen farther it is by standing on the shoulders of giants. - Isaac Newton

. Judging or criticizing ideas while generating ideas gets you nowhere. It's like stepping on the gas pedal while you have your other foot on the brake. - Robert W. Olson

. Imagination and judgment are to the thinker what a wrench and screwdriver are to the mechanic. - Robert W. Olson

. The journey of a thousand miles begins with the first step. - Oriental Proverb

. In science the credit goes to the man who convinces the world, not to the man to whom the idea first occurs. - Sir William Osler

. Allowing your self to be critical at the same time you are being creative is like trying to get hot and cold water from the same faucet at the same time. - Sidney Parnes

. Chance favors only the prepared mind. - Pasteur

. A fish would be the last living creature to discover water. - Proverb

. Behold the turtle; he makes progress only when his neck is out. - Proverb

. Words are at least the tombs of ideas. - Santayana

. Some men see things as they are and ask, "Why?" I see things as they have never been and ask, "Why not?" - George Bernard Shaw

. When I was a young man, I observed that nine out of ten things I did were failures. I didn't want to be a failure, so I did ten times more work. - George Bernard Shaw

. Doubt is uncomfortable but certainty is ridiculous. - Voltaire

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PROBLEM SOLVING: OVERVIEW

- Problem Solving: Heuristics for Independent Learning

- Problem Solving Hierarchy
    Creative Learning Model: Expanded View

- Teacher Self-Evaluation

- Problem Solving Strategies
    Basic Strategies
        . Checklist for Formal Problems
        . Questions in Metacognition

- Problem Solving Models
    Scientific Method: Induction and Deduction
        . Comparison Chart
        . Content Area Applications
        . Introducing a Skill
            - A Deductive Strategy
            - An Inductive Strategy

    Creative Problem Solving (CPS)
        . Explanation of Steps
        . Application of the Model: A Classroom Problem
        . Example of a Simplified CPS Model
        . Suggestions for Utilizing CPS
            - Life Situations
            - Curriculum Integration
            - Independent Investigations
        . Specific Objectives for CPS

(continued)

Other Problem Solving Models

- Inductive Thinking
- Checklist for Problem Solving
- Problem Solving from Conceptual Blockbusting
- Decision Making Model
- Quality Circle Process
- Whole Mind Approach
- Synectics
- Independent Study Plan

- Obstacles to Effective Problem Solving
  Summary Outline
  Suggestions for Overcoming Obstacles

- Suggestions for Creating a Problem Solving Environment

- Bibliography for Problem Solving Strategies

PROBLEM SOLVING

Basic strategies, such as trial and error and sequential models, are important tools for effective problem solving. Other strategies, or heuristics, have been described throughout this guide. Problem solving is a complex process which involves the integration of questioning skills, critical thinking, and creative thinking. All learners need to develop effective problem solving strategies; academically talented students need a greater variety of strategies to facilitate independent learning. Problem solving is multidisciplinary, but different approaches may be preferred for math, science, or language arts. Research, artistic expression, and life experience create problems requiring diverse solutions. Therefore, problem solving should be developed as a system of complex process skills which enable the learner to produce a desired outcome as efficiently as possible.

Students should have the opportunity to apply a variety of strategies in a variety of learning contexts with ample practice and evaluative feedback. Training in problem solving should develop procedures for selecting and applying a strategy appropriate to the problem situation; training should also include strategies for overcoming affective obstacles. The learner needs to recognize that some frustration is inherent in problem solving; that resolution may necessitate the repetition of steps in a problem solving model; and that a willingness to be patient, to be persistent, and to be a risk-taker will eventually overcome most difficulties. Perhaps having a positive questioning attitude is the most important asset for a problem solver to have. Students should be encouraged to develop problem solving processes which complement individual learning styles and to utilize a balance of convergent and divergent thinking skills.

The teacher can further help the learner to overcome obstacles to problem solving by providing a classroom environment in which risk-taking is encouraged and original thinking is valued. Time on task may need to be expanded or contracted depending on the learning situation. The teacher's role as model and facilitator allows students to recognize new relationships, to set criteria, to make decisions, and to develop a proficiency for identifying meaningful problems.

An ideal goal for effective problem solving is perhaps one in which the learner recognizes that a person utilizes a process to generate a product.

Problem Solving Hierarchy

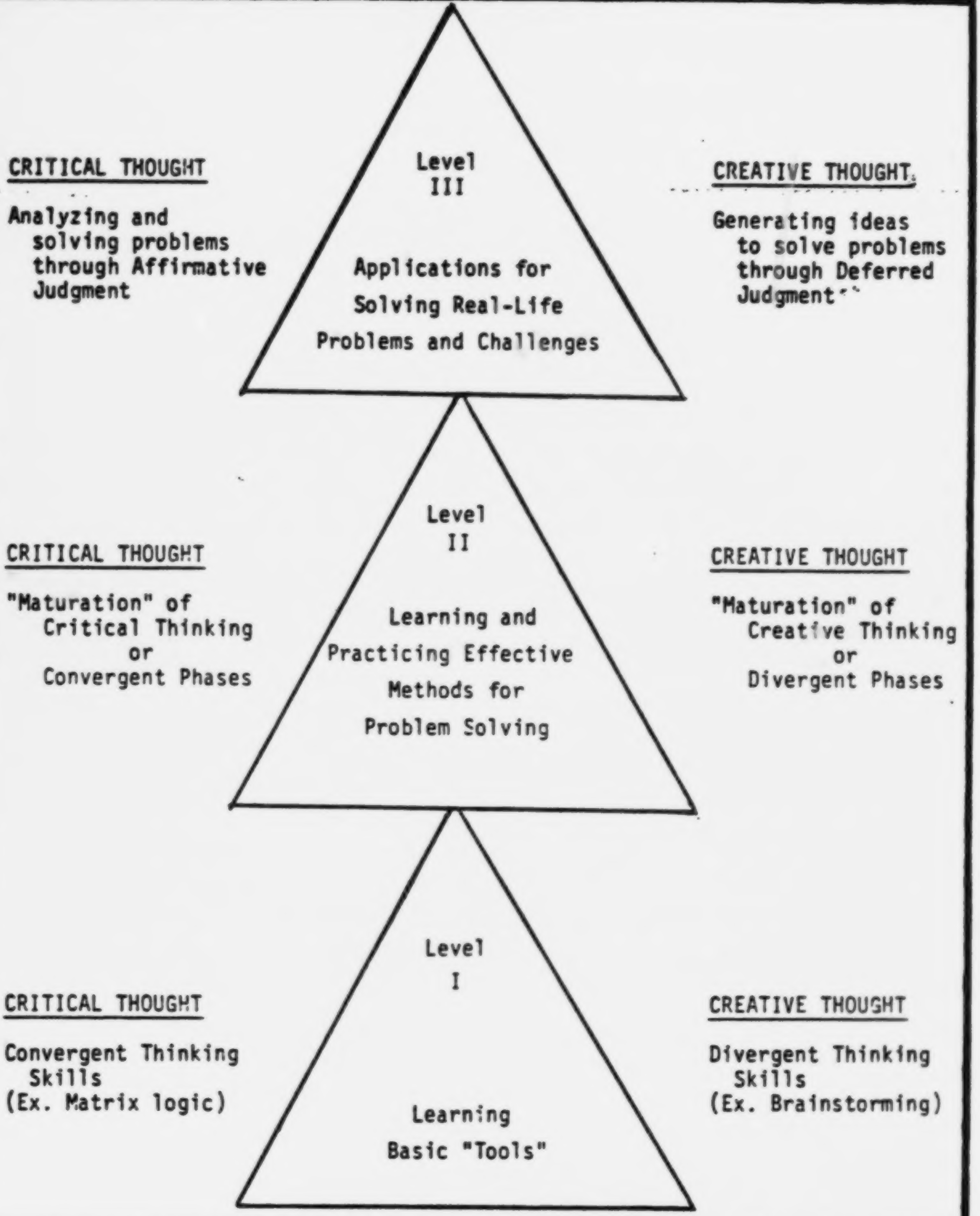
Gifted education authorities, such as Renzulli and Treffinger, continually emphasize the need to have students solve problems that deal with real life experiences. In the tri-level model of problem solving, Treffinger shows a relationship between several complex processes: convergence and divergence, critical and creative thought, and levels of learning. (See p.110 for the original "Model for Encouraging Creative Learning.") Students need opportunities to integrate basic knowledge and skills (Level I) with practiced applications for problem solving strategies (Level II) such as Creative Problem Solving (CPS). Whenever possible, students should be able to apply such techniques to real problems they have identified for themselves (Level III).

Since most problems, to which students are exposed, are of the textbook variety, students require extensive practice in the identification and definition stages of problem solving. Once problems worthy of consideration have been defined, students will need to practice when and how to use a particular strategy. Level I strategies, such as brainstorming and matrix logic, should be directly taught, but then applied toward meaningful learning objectives at Levels II and III. Students need to recognize the purpose for each strategy and for each step of a procedure. Through metacognition, the analysis and evaluation of one's thinking process, students can develop an appreciation and respect for problem solving strengths and weaknesses.

Solutions and outcomes can be tailored to individual interests or abilities by providing options for the final form of products, but students may require guidance and practice in the selection of criteria appropriate for making judgments. Treffinger distinguishes between "deferred judgment," withholding any criticism, and "affirmative judgment," the willingness to accept ideas and make them better. These evaluative attitudes may be applied within the same procedure but at different stages. For example, in CPS at the "Idea-Finding" stage, students should defer judgment during brainstorming activities; however, during "Solution - Finding," students need to start refining ideas according to criteria they have established.

The ultimate goal is to have students transfer problem solving strategies to real-life situations, but they should also be able to see how such strategies are interwoven into every aspect of the curriculum.

CREATIVE AND CRITICAL THINKING IN PROBLEM SOLVING: AN EXPANDED VIEW



Level III

Applications for Solving Real-Life Problems and Challenges

CRITICAL THOUGHT

Analyzing and solving problems through Affirmative Judgment

CREATIVE THOUGHT

Generating ideas to solve problems through Deferred Judgment

Level II

Learning and Practicing Effective Methods for Problem Solving

CRITICAL THOUGHT

"Maturation" of Critical Thinking or Convergent Phases

CREATIVE THOUGHT

"Maturation" of Creative Thinking or Divergent Phases

Level I

Learning Basic "Tools"

CRITICAL THOUGHT

Convergent Thinking Skills (Ex. Matrix logic)

CREATIVE THOUGHT

Divergent Thinking Skills (Ex. Brainstorming)

Adaptation of the Creative Learning Model by Donald J. Treffinger, from notes taken at the Maryland Conference on Gifted & Talented Education, Baltimore, Maryland, May 31, 1984. Printed with permission.

TEACHER SELF-EVALUATION FOR PROBLEM SOLVING

I create a problem solving environment in which students have the opportunity to:

__ 1. Be sensitive to the existence of problems and define them accurately.

__ 2. Develop questions appropriate to specific problem situations.

__ 3. Accept challenges and to set goals for one's own learning.

__ 4. Remain open-minded about new and different ideas.

__ 5. Visualize relationships.

__ 6. Recognize the value of reasoned assumption and precise thinking.

__ 7. Generalize on the basis of selected attributes, factors, or characteristics.

__ 8. Decide when it is appropriate to defer judgment.

__ 9. Generate, evaluate, and revise original ideas.

__10. Select appropriate problem solving strategies in order to reach a solution.

__11. Work independently, but value cooperative interaction.

__12. Take risks and learn from one's mistakes.

__13. Maintain a positive self-image and develop confidence as a problem solver.

__14. Solve problems at the literal, critical, and creative levels.

__15. Establish standards for critiquing problem solutions using affirmative judgment.

__16. Recognize the difference between convergent and divergent outcomes.

__17. Learn and practice a variety of methods for problem solving.

__18. Apply problem solving strategies to real-life situations and challenges.

__19. Verbally analyze one's problem solving style.

__20. Value and appreciate creative strategies and solutions employed by themselves and others.

Problem Solving Strategies

Problem solving strategies consist of general techniques that can be applied to a variety of dissimilar problems, problem settings, and subject matter. They are techniques which are not necessarily problem-specific. They are procedures that students can use to make a problem clearer, simpler, or more manageable. According to Suydam, et al. (p. 21), there are four important points associated with a strategies, or heuristics, approach to solving problems:

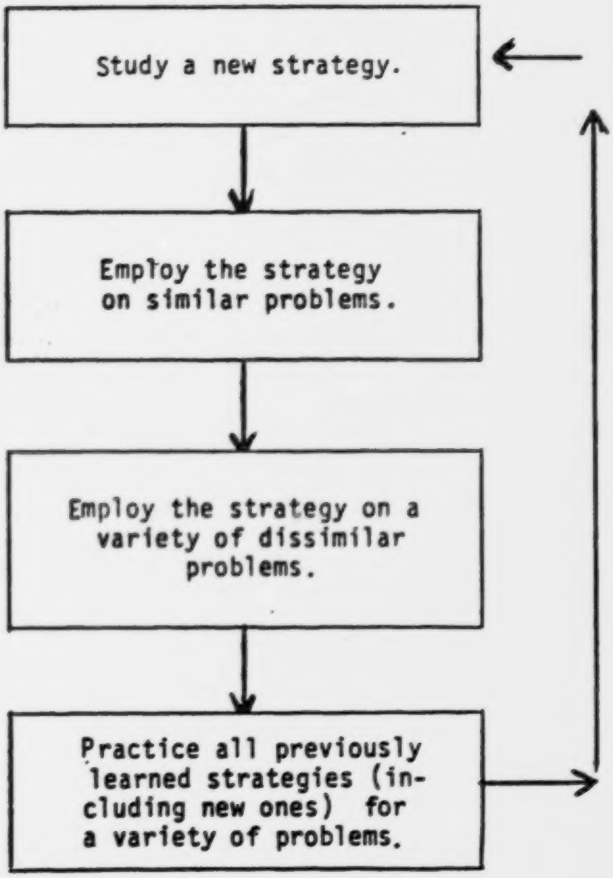
a. Strategies are general skills or abilities that can be learned.

b. Strategies are useful in a variety of problems.

c. Strategies may be used singly or in combinations to solve a single problem.

d. Strategies give the individual the tools with which to begin or continue productive work on a problem.

Students can become more proficient problem solvers by gaining an awareness of the ways specific strategies are used, developing others, and analyzing their thinking processes as they solve problems. The following plan may be used to help students become better problem solvers by using a strategies approach (Suydam, 1980).


Study a new strategy.
Employ the strategy on similar problems.
Employ the strategy on a variety of dissimilar problems.
Practice all previously learned strategies (including new ones) for a variety of problems.

Basic Strategies

The following checklist provides basic strategies from which students can select an approach for solving a formal problem, i.e., one in which the problem has already been defined for the student, and for which there is a known answer:

- Use trial and error
- Look for a pattern
- Act it out
- Make a drawing, figure, or graph
- Account for all possibilities (systematically)
- Construct a table
- Guess and check
- Work backwards
- Think of counter examples
- Select appropriate notation
- Restate the problem (in your own words)
- Identify wanted, given, and needed information
- Write an open sentence
- Identify a subgoal
- Solve a simpler (or similar) problem
- Change your point of view
- Check for hidden assumptions
- Use a resource.

Students must raise questions which enable them to decide which strategy is most appropriate. Furthermore, students also need to question how effective the strategy will be in solving the problem. The following problem provides an example of the usefulness of the questioning attitude which is vital to metacognition (thinking about thinking).

> Elaine, Judy, Nancy, Sue, and Ruth are running in a race. Half-way through the race, they are in these positions:
>
> Elaine is 30 yards behind Judy.
>
> Judy is 40 yards ahead of Nancy.
>
> Nancy is 20 yards behind Sue.
>
> Ruth is 50 yards ahead of Elaine.
>
> Sue is 40 yards behind Ruth.
>
> At this point, who is winning the race?
>
> Who is second? Third?

Use of Questions in Metacognition

- QUESTION: Can I use trial and error?

  RESPONSE: What am I going to try? How can I know if I've made an error?

  CONCLUSION: Eliminate trial and error for now. Use trial and error to find the best strategy for this problem.

- QUESTION: Will the look for pattern strategy work?

  RESPONSE: There is a pattern -- each person appears to be 10 yards from another. But the information is complicated, and I can't visualize it.

  CONCLUSION: Maybe I need a strategy which allows me to picture the correct order.

- QUESTION: Could I picture it by the act it out strategy?

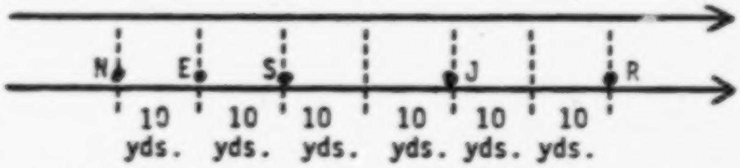
  RESPONSE: It might work, but I can't leave my seat, and I have to solve this one alone.

  CONCLUSION: If I can't get someone to act it out with me, maybe I could use make a drawing, figure or graph.

- QUESTION: What do I need to draw in order to get the people in the right order?

  RESPONSE: I could draw a diagram of the field, mark off 10 yard sections, and show where the people fit on the field.

  CONCLUSION: The make a drawing... strategy should work. I'll try it, and if it doesn't work, I'll have to try something else.



- QUESTION: Can I answer the questions to the original problem?

  RESPONSE: Yes, I can see that Ruth is winning the race, Judy is second, and Sue is third.

  CONCLUSION: Yes, this was an appropriate strategy for this problem, and when I have to arrange items in order, a drawing or diagram may be helpful.

Problem Solving Models

A list of basic strategies may be very helpful for solving formally stated problems. However, selection of the appropriate strategy may be random, and more than one may be needed to solve a problem. Such basic strategies are problem-specific, and although they can be used in varying combinations, they do not constitute a system, nor are they effective with open-ended problems.

Both basic strategies and problem solving models require the problem solver to make choices, to identify the attributes of the problem, to have a questioning attitude and a metacognitive approach, to acquire experience in using the various approaches, and to select the most appropriate strategy for the problem situation. However, although problem solving models may include the use of basic strategies, they are comprehensive sequential systems which allow application to a wide variety of problems which have varying degrees of complexity.

Most problem solving models involve a step-by-step procedure which invariably include certain fundamental concepts:

- Defining problems
- Collecting relevant information
- Forming ideas to be tried
- Testing ideas
- Forming conclusions about the success of ideas.

Problem solving models can be used in situations requiring the investigation and research of topics or situations for which the answers may be open-ended. They involve an interplay of convergent and divergent thinking. Students become more proficient problem-solvers when they are able to analyze the procedure and the mental processing they used. Such analysis, of course, is metacognition. In certain problem situations or for certain students, one problem solving model may be preferred over others. Students should become familiar with several models in order to recognize those which suit their personal learning styles or those which are more applicable to specific conditions.

Models for the Scientific Method

The scientific method provides an organized approach for formulating and testing hypotheses. This procedure is usually applied to problems of investigation and research. Although it is frequently taught in connection with the natural, physical, and social sciences, it can also be used in other disciplines. Students need to be aware that science is a process of investigation rather than a subject or body of knowledge. As students use the scientific method, they should realize that they need to evaluate the process and maintain a questioning attitude at each step, and that at any point it may be necessary to return to a previous step to do more work. For example, the conclusion may be illogical, the problem may not have been clearly defined, the hypothesis may be incorrectly stated, or the data may be incomplete or misinterpreted.

Models for the Scientific Method

	Induction		Deduction
I.	Define the problem	I.	State the problem
II.	Gather data	II.	Formulate the hypothesis
III.	Formulate the hypothesis	III.	Observe and experiment
IV.	Verify the hypothesis	IV.	Interpret the data
V.	Draw a conclusion	V.	Draw conclusions

The scientific method involves the integration of inductive and deductive reasoning.

Inductive reasoning allows the investigator to infer that a general law or principle might be formed based on experience or observations. The assumption thus formed is held to be true only as long as an exception to the rule is not found.

Deductive reasoning is the process used to test a hypothesis, and the results are considered conclusive based on the conditions in the limited or controlled situation.

Because the two processes frequently overlap in the scientific method, it is not always possible to delineate the differences; the following chart should prove helpful in defining the two processes.

COMPARISON OF INDUCTION AND DEDUCTION

INDUCTION	DEDUCTION
Specific → General	Specific ← General
Infer a general law or theory from a specific instance.	Conclude a specific instance supports a general law or theory.
Infer a hypothesis from assumptions.	A hypothesis is tested with observable data.
Inferential reasoning is not limited to existing evidence.	Conditional reasoning is based on evidence in a limited situation.
More information is in the conclusion than is given in the premises.	Conclusions do not go beyond original information.
Conclusions are based on incomplete evidence.	Conclusions are based on definitive evidence.
There may be elements of doubt and uncertainty.	Answer or evidence satisfies the question or supports the hypothesis.
Questions are raised.	Answers are provided.
Unlimited possibilities are considered.	A limited set of possibilities is considered.
Results make a generalization which is held to be true until an exception is found.	Results are considered true given the circumstances or conditions.
Hypotheses cannot be stated as true or false, valid or invalid, since the information is inconclusive.	Hypotheses are considered to be supported or not supported, valid or invalid, based on available data.
A conclusion is always open to doubt even if the premises appear valid.	A conclusion is held to be valid unless one rejects one or more of the premises.
→ Generalization Supported	Specific instance proven ←

CONTENT AREA APPLICATION OF THE SCIENTIFIC METHOD

INDUCTION	DEDUCTION
Language Arts	
. Research a controversial topic in order to form an opinion.	. Write a composition to support an opinion.
. Compose a mood poem using the list of similes and metaphors.	. Identify the mood of a poem and find examples of figurative language that create the mood.
Social Studies	
. Compare the contributions of Martin Luther King and Harriet Tubman to civil rights today.	. Based on a selected civil rights article, write the contributions of each black leader.
. What were the conditions in Europe that led to the founding of the colonies?	. How did religious beliefs contribute to the founding of the colonies?
Science	
. What conclusions do you come to when you observe the onion cells' reaction to salt water?	. Why did the cell walls in the onion skin collapse when exposed to salt water?
. What explanation can you give about why the capped bottle of water broke, and the uncapped bottle did not, when placed in the freezer?	. Give an example to prove that water takes up more space when frozen.
Math	
. What conclusions do you arrive at when you compare the differences between the set of squared numbers? 1,4,9,16...,	. If the last odd number between a pair of squared numbers is 11, what is the next squared numeral?
. Bisect the following diameters. What conclusion can you make about each segment?	. Find the radius of each circle.

INTRODUCING A SKILL: AN INDUCTIVE STRATEGY

STEP 1 INTRODUCE THE SKILL.

- Give its label or name.
- Define it.
- Give ways it can be used in daily experience.
- Give snynonyms.

STEP 2 EXPERIMENT WITH THE SKILL -- DO IT.

- Use the skill (as best one can) to accomplish a task.
- Have the students work in pairs, groups, or alone.
- Use content appropriate to curriculum.

STEP 3 REFLECT ON WHAT WAS DONE.

- Articulate what thinking went on as students engaged in the skill.
- Identify the steps/rules and the best sequence.
- Clarify operations used.
- Focus on skill, not on substantive learnings.

STEP 4 APPLY SKILL TO NEW DATA.

- Review steps or procedure.
- Carry out procedure.
  - Decrease guidance as students increase competency.
  - Focus on the skill, not content.
  - Use content from the curriculum.
- Have students work in pairs or groups.
- Provide equivalent or analogous practice.
- Use frequent, short practice with immediate feedback.

STEP 5 REVIEW THE SKILL.

- Review the steps/rules that guide skill use.
- Review the rules that direct the use of the skill and when it is appropriate to use it.
- Reflect on the relationship of the skill to other skills.

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INTRODUCING A SKILL: A DEDUCTIVE STRATEGY

STEP 1 INTRODUCE THE SKILL.

. Give its label/name.

. State its definition:

By doing it
By telling about it
By giving examples of it
By giving synonyms.

STEP 2 EXPLAIN THE SKILL.

. Tell the steps which comprise the skill.

. Show step-by-step how each operation proceeds (rule-example-rule).

. Use a concrete example to illustrate the skill, preferably an example from the life experience of the students.

STEP 3 DEMONSTRATE THE SKILL.

. Lead the class step-by-step through the skill.

- State the goal.
- Refer to steps in moving through the skill.
- Discuss content and skill steps during the procedure.

. Review by outlining the steps that constitute the skill.

STEP 4 APPLY THE SKILL.

. Have the students practice the skill with teacher guidance.

. Decrease guidance as experience increases.

. Focus on the skill as well as on the content.

. Use content from the curriculum.

. Have the students work in pairs, groups, or individually.

. Provide practice:

- Equivalent to testing/using situation
- Analogous to test situation.

. Conduct periodic reviews of steps of the skill and rules that guide its use.

STEP 5 REFLECT ON THE SKILL.

. Review the steps which comprise the skill and the rules that guide its use.

. Reflect on ways in which the skill is used and when it is appropriate to use it.

. Reflect on the relationship of the skill to other skills.

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Creative Problem Solving (CPS)

> *If we constantly grasp and hold onto the first idea that we produce, we may have to use a "big hammer" to make the idea work. The further along we take a poor idea, the bigger the hammer we must use to make it work.* - *Robert W. Olson*

Creative approaches to problem solving provide for the application of a broad range of thinking processes. Creative Problem Solving (CPS) developed by Osborn (1963) and extended by Parnes and his associates (1976) is one of the most widely used models. When taught in the classroom, CPS becomes an instructional method for assisting students to increase their resourcefulness, self-sufficiency, and productivity.

CPS has many applications. It can be used to resolve real-life problems at home and in school and can help students clarify value judgments. CPS can also be integrated into various areas of the curriculum such as a social studies unit, a literary favorite, or a reading story. When the students become proficient with this model, they should be prepared to conduct independent investigations of hypothetical problems for which there may be no traditional solutions.

CREATIVE PROBLEM SOLVING

Step	Process
Preliminary: "MESS"	. Becoming aware
1. Fact-Finding	. Getting information . Looking for causes . Asking questions
2. Problem-Finding	. Selecting and stating a manageable problem
3. Idea-Finding	. Thinking of original ways to solve the problem
4. Solution-Finding	. Deciding which ideas might work . Testing the workability of the ideas
5. Acceptance-Finding	. Designing a plan of action to resolve the problem

Each of these sequential and interrelated steps has a distinct purpose. For students to gain an understanding of the total model, each step must be thoroughly developed. More time should be devoted to steps one and two because defining the problem as accurately as possible will save time in the long run. Students need to be encouraged to thoroughly explore the initial steps to avoid having to use a "big hammer" later on. The use of appropriate evaluative strategies at each step will yield a more efficient procedure ultimately.

To assist in the successful implementation of this problem solving strategy, in-depth explanations of the CPS model and suggestions for its classroom utilization follow.

Preliminary Step: "MESS"

> CPS begins with a "MESS." In everyday life, the problems students face are very different from those they encounter in textbooks. Instead of having every detail presented neatly and concisely, students often experience only a feeling of concern or uneasiness. They may know that something is wrong or missing but may not know what it is, let alone what to do about it. This state of confusion is called the "MESS" in CPS terms.

The five CPS steps help the students approach the "MESS" in an open-minded, systematic, deliberate manner.

Step 1: FACT-FINDING

> The students gather, review, and assess all available information relating to the elusive "MESS." Who...What...When...Where...How are good guideline questions which help students determine the facts and the unknowns that may affect the "MESS."

Step 2: PROBLEM-FINDING

> As the students begin sorting the facts, many different problems or subproblems may emerge from the "MESS." During Problem-Finding, students must consider the various issues and alternatives. They must view the "MESS" from many different angles, then select and state a manageable problem. The problem is stated as clearly as possible beginning with the words, "In What Ways Might We...?" (IWWMW). The problem should be stated at least three times, each time trying to be more specific. Students then select the statement that best defines the problem.

Step 3: IDEA-FINDING

> Having defined the problem, the students generate many possible solutions. The production of many solutions can be facilitated through the use of brainstorming, attribute listing, and check-listing. It is important that the students defer all judgment at this time.

Step 4: SOLUTION-FINDING

> After the students have formulated a list of ideas, the most practical or desirable solution must be determined. Solution-Finding involves the evaluation of the ideas produced during the Idea-Finding stage and the manipulation of the best idea into a solution strategy. Students now discuss, criticize, speculate, and elaborate about each idea and its implementation. During the discussion, students brainstorm the criteria by which to judge the advantages and disadvantages of each solution. The criteria include those guidelines which must be considered before a decision can be made. The students select the most significant of the evaluation criteria and place them on a matrix with proposed solutions.

Step 5: ACCEPTANCE-FINDING

Students now undertake a final consideration of the solution to decide how best it may be implemented. Acceptance-Finding is concerned with helping good ideas become useful ideas. It involves writing a plan of action for putting the solution into effect. Students need to consider questions such as:

- **What steps need to be taken to implement the solution?**
- **Who will be involved in the process?**
- **What materials will be needed?**
- **How much time will be required to carry out the plan?**
- **Is there a target date for completion?**
- **What obstacles might hinder the succes of the solution?**
- **How might the obstacles be overcome?**
- **How can the success of the solution be determined?**

Students may not have spent sufficient time gathering facts and defining the problem. They need to recognize that verification should take place at each step and that even at this point it may be necessary to return to the "MESS."

Acceptance-Finding involves creating many alternatives and strategies, and then weaving the best of them into a plan for creative action. Each plan of action the student develops can serve as a springboard for future challenges.

> *The society which scorns excellence in plumbing because it is a humble activity and tolerates shoddiness in philosophy because it is an exalted activity will have neither good plumbing nor good philosophy. Neither its pipes nor its theories will hold water.*
>
> *- John W. Gardner*

Application of the CPS Model

The following example illustrates one way CPS can be used to solve a classroom problem.

The "MESS" Our class is constantly getting into trouble in the cafeteria.

Step 1: FACT-FINDING

1. What kind of trouble is occurring?
2. Who or what seems to be causing the trouble?
3. When is the trouble happening?
4. Where is the trouble occurring? (in line? at the tables? outside?)
5. Is our entire class involved or just a few people?
6. Are any other classes involved?
7. Are the same people always involved?
8. How are you expected to behave in the cafeteria?
9. What are the cafeteria rules?
10. Does everyone know and understand the rules?
11. Do the rules seem to be fair?
12. What rules are being broken?
13. What do the cafeteria aides do when rules are not being followed? Are any warnings given?
14. Is any punishment given? By whom? What is it?
15. Does everyone know the consequences of breaking the rules?
16. Does everyone think the punishment is fair? Why or why not?
17. What are the cafeteria aides' concerns?

Step 2: PROBLEM-FINDING

"In What Ways Might We..."

... Make the cafeteria quieter?

... Stop the students from shouting in the cafeteria?

... Keep our class quiet?

Final Statement of the Problem:

In what ways might we work together as a class to decrease the noise level at our cafeteria tables?

Step 3: IDEA-FINDING

1. If the class gets a bad report, there will be silent lunch for two days.
2. Students must sit in assigned seats.
3. Chronic talkers hold their hands over their mouths.
4. Entire class goes on voluntary silent lunch.
5. Students are assigned to act as class monitors.
6. Chronic talkers are separated from the group.
7. A signal system is established which reminds students of the noise level.
8. Well-behaved students may sit near friends.
9. Reward system for quiet tables is established.
10. Aides are asked always to give one warning before reporting a class or an individual to the teacher.
11. Students take a quiet activity (book, puzzle) to do during lunch.
12. A buddy system is set up. Students are responsible for reminding their partners to keep their voices low.
13. Individual rewards for quiet students are given.
14. Peer pressure is encouraged. If one person misbehaves, the entire class is punished.
15. A mother watches the class.
16. The teacher eats with the class.
17. Cafeteria aides send noisy students to the office.
18. Noisy students eat in the classroom.
19. A class party is held if the class is well-behaved for one month (example: popcorn, ice cream).
20. Lunch is purchased from a fast-food chain if the class is well-behaved for one month.
21. Lunch is purchased from a fast-food chain for all students who have not been reported.
22. The teacher calls the parents of a child who has been reported.
23. If students are reported, they must call their parents immediately.
24. If students are reported, students must write a letter to their parents.

Step 4: SOLUTION-FINDING

RATINGS

4 = Excellent
3 - Good
2 - Fair
1 - Poor
NA - Not applicable

Note: Checks or plus/minus signs may also be used.

	CRITERIA								
SOLUTIONS:	Needs cooperation of entire class	Makes lunch an enjoyable experience	Effectively controls noise	Requires little time for planning	Is realistic	Is fair to all	Makes class self-reliant	Helps aides	Total
Students sit in assigned seats.	1	1	3	2	4	1	1	4	17
The entire class goes on voluntary silent lunch.	4	1	4	4	1	1	1	4	20
Class monitors are appointed.	4	3	3	2	4	4	4	4	28
A signal system is used.	4	3	3	3	4	4	4	4	29
Well-behaved students sit near friends.	2	4	2	2	3	4	4	2	23
One warning is given by an aide.	4	3	3	4	4	4	3	3	28
A "Buddy" system is used.	4	3	3	2	3	4	4	4	27
Peer pressure is given.	4	1	3	4	1	1	1	4	19
The teacher eats with the class.	NA	2	4	4	1	1	1	4	17
Once a month there is a fast-food lunch reward for well-behaved students.	4	NA	NA	1	3	3	3	NA	14
Students who misbehave write a letter to parents.	1	3	3	3	4	4	1	3	22

Step 5: ACCEPTANCE-FINDING

The highest-scoring ideas that have emerged during Solution-Finding include:

- Signal system
- Class monitors
- One warning from aides
- Buddy system
- Well-behaved students sit near friends.

The solution to the problem integrates the high-scoring ideas with ideas generated during Idea-Finding and Solution-Finding stages and leads to the development of an action plan.

ACTION PLAN

Solution	Example
1. Implement a class self-monitoring system.	A warning signal is to be used by class monitors if the noise level increases.
2. Establish a consistent warning procedure with the cafeteria aides.	If misbehavior continues after one general warning, the names of offenders will be submitted to the teacher.
3. Determine a reward for improved cafeteria behavior.	Well-behaved students may sit near friends. Lunch is purchased periodically from a fast-food chain.
4. Determine appropriate and consistent punishment for offenders.	Student/teacher communicates with parents. -Student writes letter to parents for first offense. -Teacher telephones parents for second offense. -Student/parent/teacher conference is held after third offense.
5. Establish an evaluation procedure. What questions should be asked? What criteria will show that the solution is successful?	Periodic class meetings are held to discuss: -Effectiveness of monitoring systems -Suggestions for improvement -Comments from the cafeteria aides.

Designing appropriate evaluation guidelines may present another "Mess." A new CPS procedure may be initiated, but simplified, as in the following example.

Example of a Simplified CPS Model

1. Students brainstorm the kinds of questions they need to ask when evaluating an action plan, for example:
    - *How will we know if the plan is working?*
    - *Who will tell us if things go wrong?*
    - *How can we find out how people feel about the plan?*
    - *How can we advertise the plan and the results?*
2. Students evaluate the list, discuss the problem, select the three most important items, and finally select the most important. Rank ordering was used to identify the most important idea in this case.
    - *How can we find out how people feel about the plan?*
3. Brainstorm answers to the most important questions or items developed in Steps 1 and 2. Solutions may be full or partial ways of solving the problem.
    - *Get people to write letters.*
    - *Conduct interviews.*
    - *Watch the behavior of everyone involved.*
    - *Talk to the principal.*
    - *Form an evaluation committee.*
    - *Conduct a survey of everyone involved.*
4. The students take the ideas from Step 3 and create a synthesis for a solution. The solution may be varied, but it should have some cohesion.
    - *Develop and administer a questionnaire to evaluate the cafeteria plan (see preceding page) which will be administered to teachers, students, and administrators.*
5. Develop a plan for implementing the solution. Who? What? Where? When? How? Write the plan and turn it in.

SIMPLIFIED ACTION PLAN

- PROPOSAL: *Develop and administer a questionnaire to find out how everyone feels the cafeteria plan is working.*
- MATERIALS/RESOURCES: *List of questions, format, guidance counselor, paper, typist, ditto machine.*
- PROCEDURE:
    1) *Form a committee to prepare the questionnaire.*
    2) *Get approval from the principal.*
    3) *Give the questionnaire to the people concerned.*
    4) *Tabulate the results.*
    5) *Make a graph or chart to show the results.*
- RESULTS AND CONCLUSIONS: *(Analysis of the results may lead to another problem.)*
    1) *How can we share the results of our study?*
    2) *In what ways can we modify the cafeteria plan so that more people are satisfied?*
    3) *Can we transfer this plan to another situation?*

Suggestions for Utilizing Creative Problem Solving

1. Life Situations

. Home Life

- Completing chores
- Finishing homework assignments
- Planning celebrations and/or vacations
- Scheduling use of the television
- Budgeting allowance
- Resolving disagreements with siblings
- Conserving energy in the home.

. School Life

- Welcoming a new student
- Resolving conflicts with classmates
- Increasing/improving contributions to class discussion
- Planning free-time activities
- Improving quality of written work
- Resolving behavior problems
- Organizing and completing independent or small group projects.

. Value Judgments

- Your pet hamster, Joey, escaped from his cage last night. In order to have a pet hamster, you promised to take care of him and make sure he remains in his cage. No one knows Joey is not in his cage except you. What should you do?

- Yesterday your mother sent you to the grocery store for a loaf of bread. While you were at the store, you saw one of your friends take a bag of candy from the shelf and hide it in his pocket. When he checked out, he did not pay for the candy. What should you do?

- Jeremy and Prudence have just arrived in Plymouth on the Mayflower. All of the children are looking for firewood to use for cooking supper on the beach. Jeremy and Prudence wander into the woods on their search and find themselves face-to-face with a tall Indian who does not speak their language. What should they do?

2. Curriculum Integration of CPS

. Social Studies

- How could the conflict between the Plains Indians and settlers have been resolved without forcing the Indians off their land?
- What other means of communication could Paul Revere have used to warn the colonists that the British were coming?
- Suppose your County Council representative has agreed to sponsor one law that would improve your neighborhood. What would you do?

. Science

- The superintendent has announced that all schools must reduce their energy comsumption by 10%. How would you attain this goal?
- Your school has been awarded $1,000 to improve the school grounds. What is the best way to spend the money?
- The Student Council has decided to convert a wooded area on the school grounds into a bird sanctuary. What would you do to make this project a success?
- Design a vehicle that can travel a distance of at least 20 feet using only a mousetrap for energy.

. Mathematics

- Design a way to measure tall objects that are beyond your reach.
- Design a method by which you can measure a given length without traveling the distance.
- Retaining approximately the same area, redesign the floor space of your school building making it more accessible to the handicapped.

. Language Arts

- After reading City of Gold and Lead by John Christopher, design a plan to capture a tripod or master and destroy the three cities.
- Read newspapers and current periodicals to identify a current problem situation. Develop a creative solution to the problem.
- If you were asked to accompany Professor Sherman (The Twenty-One Balloons) on his next voyage around the world, what modifications would you make to the balloon?
- Karana (from Island of the Blue Dolphins) has been rescued and is coming to live with your family. How can you help her adapt to her new surroundings?

3. Independent Investigations for CPS

. Once the students are proficient with CPS, the following topics can provide a basis for independent research. The problems were developed by E. Paul Torrance (1981) as part of his Future Problem-Solving Bowl.

- Technology allows us to see and hear people, events, and places all over the world and in space. Television provides us with news reports and movies, vastly decreasing the need to read a newspaper or book. Computers can store diagrams and pictures as well as information, and then can give out the answers or required data in a human-like voice. Road signs, too, are eliminating writing from their messages and putting them into internationally understood symbols. Therefore, it is possible that the need to read will one day be eliminated.

  Identify the possible problems. Restate the major problem for creative attack and seek solutions to it.

- Immunization against many common diseases is well-known in the advanced nations of the world, but virtually unknown to the people of a very large part of the world. In the future, it is almost certain that medical research will develop immunization against still more common diseases. It is possible, also, that a combined effort by the advanced nations could bring the benefits of immunization to people throughout the world. The problem is gigantic in scope.

  Identify possible problems. Restate the major problem for creative attack and seek solutions to it.

- Many futurists envision the virtual elimination of currency through the use of credit accounts. Upon completing a transaction in a store, the purchaser's account would be automatically scanned. If the proper balance was present, credits would be transferred from the buyer to the seller. Employers would write credit notes to the banks of their workers on payday, transferring credits from the business account to those of the employees. The result would be a cashless society.

  What possible problems do you foresee? Restate the major problem for creative attack and seek solutions to it.

- Residents of major cities are facing two dilemmas--an increase in traffic congestion and a decrease in the availability of building space. These conditions may lead to the use of high-rise buildings not only for apartments but for commercial purposes as well. Each building would then represent an urban microcosm. Residents would be able to live, work, and shop in the same building. Services such as doctors, hair stylists, laundries, and theaters would also be available.

  Identify the possible problems. Restate the major problems for creative attack and seek solutions to it.

- The pet population in America has tripled in the last twenty years. Dogs and cats lead the list of most popular pets, though exotics like lions, boa constrictors, and monkeys are not far behind. The pet owner willingly puts out hundreds of dollars a year for food, hygienic equipment, and accessories for the pet(s). Pet shops and pet food companies are doing a major business, and projections show a rise as Americans become increasingly pet conscious.

  What problems are there in this pet boom? What is the most important problem? Restate the major problem for creative attack and seek solutions to it.

- In recent years, television has successfully proved that it can be effectively used as a tool in education. Sesame Street and Electric Company have shown that math and reading can be taught on television. This, combined with the ever-expanding use of computers and their lowering cost, may mean that education will soon be available at home. Lessons could be watched on television, and assignments done and checked by a computer outlet in the home. This would allow for students to move at their individual levels in each subject.

  Can you identify any possible problems? Restate the major problem for creative attack and seek solutions to it.

> *When I want to discover something, I begin by reading up everything that has been done along that line in the past — that's what all these books in the library are for. I see what has been accomplished at great labor and expense in the past. I gather the data of many thousands of experiments as a starting point, and then I make thousands more.*
>
> *- Thomas Edison*

Specific Objectives for Creative Problem Solving

A summary of objectives for CPS by Feldhusen and Treffinger (1980) may serve as a checklist for other problem solving models as well.

1. Be sensitive to problems.

   . Given a "MESS," the student should be able to describe many specific problems which could be appropriately attacked.

   - Describe many elements of a situation.
   - Employ a checklist to extend analysis of possible problems.

2. Be able to define problems.

   . Given a perplexing situation, the student should:
   - Recognize the "hidden" or "real" problem which may underlie the stated question.
   - Broaden the problem, or redefine it by asking "why."
   - Redefine or clarify the problem by changing verbs.
   - Identify several possible sub-problems.

3. Be able to break away from habit-bound thinking.
   - Describe habitual ways of responding.
   - Evaluate the effectiveness of those responses.
   - Develop several possible alternative ways of responding.
   - Select promising alternatives.
   - Develop and implement a plan for using new responses.

4. Be able to defer judgment.

   . In viewing a perplexing situation:
   - Produce many responses.
   - Give responses without imposing evaluations.
   - Refrain from evaluating others' responses.

5. Be able to see new relationships.

   . Given perplexing situations or stimuli:
   - Identify similarities among objects or experiences.
   - Identify differences among objects or experiences.
   - List ideas for relating or comparing objects/experiences.

6. Be able to evaluate the consequences of one's actions.
   - Identify a variety of criteria for evaluation.
   - Develop many possible criteria for any problem.
   - Demonstrate deferred judgment with respect to criteria.

7. Be able to plan for implementation of ideas.

   . Given a problem and a proposed solution or set of solutions, the student should:
   - Identify specific sources of difficulty in implementation.
   - Use checklists to recognize and anticipate obstacles.
   - Specifiy a plan for facilitating acceptance.

8. Be able to observe carefully and discover facts.
   - Given a perplexing situation or experience:
     - List many attributes of the situation.
     - Describe factors influencing observations.
     - Describe difficulties in "changing one's viewpoint."
     - Describe techniques for breaking the limiting set of past experiences.
     - Describe the features, characteristics, and functions of important parts of the situation.
9. Be able to use effective techniques for discovering new ideas.
   - Describe and demonstrate the use of several techniques for facilitating idea production.
10. Be able to refine strange ideas into useful ones.
    - Given a problem and a selection of apparently "silly" ideas:
      - Describe ways the ideas might be made more useful.
      - Demonstrate ways to define and use essential criteria in evaluating ideas.
      - Describe problems associated with vague criteria.
      - Demonstrate ways to define and use essential criteria in evaluating ideas.
      - Describe and demonstrate the use of analogy in finding new ideas.
11. Be able to describe and use a systematic approach.
    - Define, illustrate, and implement in a problem each of the following stages in creative problem solving: fact-finding, problem-finding, idea-finding, solution-finding, and acceptance-finding.
12. Be able to describe the influence of interpersonal relationships on problem solving, and to illustrate problems associated with interpersonal relationships.
    - Become aware of one's own potential and limitations.
    - Work actively to attain potential and overcome limitations.
    - Be willing to master new ideas and apply them in real problems.
    - Be willing to share problems and ideas with others.

> *The method of our time is to use not a single but multiple models for exploration - the technique of the suspended judgment is the discovery of the Twentieth Century as the technique of invention was the discovery of the Nineteenth.*
>
> *- Marshall McLuhan*

Other Problem Solving Models

. Inductive Thinking Model (developed by Hilda Taba and summarized in Joyce and Weil, 1980, p. 59)

Taba's Inductive Thinking Model is an expanded variation of a basic inductive model used in the Scientific Method (p. 159).

A. Concept Formation
   1. Enumerate and list.
   2. Group.
   3. Label, categorize.

B. Interpretation of Data
   1. Identify dimensions and relationships.
   2. Explain dimensions and relationships.
   3. Make inferences.

C. Application of Principles
   1. Hypothesize, predict consequences.
   2. Explain and/or support hypotheses and predictions.
   3. Verify the hypothesis or prediction.

. Checklist for Problem Solving (from Successful Problem Solving Techniques by Carole Greenes)

This model provides a procedure for a "trial and error" approach and incorporates other basic strategies (p. 156) into a sequential system.

A. State in at least two ways what you are to find out.

B. List all the information you can about the problem.

C. Check for assumptions.

D. Simplify the problem.

E. Display information as in a table or a graph.

F. Develop a pattern.

G. Make different cases.

H. Guess either the solution or first step.

I. Try your best idea.

. Problem Solving Steps (from Conceptual Blockbusting by James Adams)

Adams' model provides a comprehensive approach to creative problem solving and stresses the importance of ongoing positive evalation and elaboration of ideas.

A. Problem definition

B. Idea production

C. Idea evaluation

D. Decision

E. Detail and optimization

F. Action planning

G. Implementaion and feedback

. Decision Making Model (from "Trade Offs," Canadian Foundation for Economic Education)

Making decisions is central to all problem solving. The focus of this model is on the selection and evaluation of criteria and alternatives.

A. Define the problem.

B. List the alternatives.

C. State the criteria.

D. Evaluate the alternatives.

E. Make a decision.

. Quality Circle Process

The concept of Quality Circles was developed several decades ago by Japanese industrialists to improve productivity, motivation, and the quality of workmanship. In a Quality Circle, a group works together to develop solutions to current problems. Throughout the process there is a strong emphasis on analysis and convergent thinking.

Step 1. Problem selection by formal brainstorming

Step 2. Cause-effect analysis

Step 3. Solution identification

Step 4. Recommendation

Step 5. Implementation

Step 6. Evaluation

- Whole Mind Approach (from "Reaching Your Personal Best Through the Whole Mind Approach" by Dr. Ronald L. Rubenzer, 1983)

  This model places a heavy emphasis on visualization strategies (p.129). The acronym formed by the key terms highlights the effectiveness of this model for creative thinking. Relaxation and envisioning are designed to permit the expression of ideas attributed to "right brain" production.

  A. Collect the facts.

  B. Relax.

  C. Envision.

  D. Articulate.

  E. Try out.

  F. Evaluate.

- Synectics (from *Synectics* by William J.J. Gordon)

  Synectics is a group problem solving process for developing creative ideas. Problem solvers use analogies and metaphors as a way of making the familiar strange, and the strange familiar. A demonstration of the use of analogous relationships is provided in the section on Creative Thinking in this guide. The following sequence for using synectics has been summarized by Joyce and Weil (1980, pp. 185-186).

  A. Substantive Input

  - Gather information on a new topic.

  B. Direct Analogy

  - Form and describe a direct analogy.

  C. Personal Analogy

  - Learners "become" the analogy.

  D. Comparing Analogies

  - Find similarities between the new material and the analogies.

  E. Explaining Differences

  - Explain where the analogy does not fit.

  F. Exploration

  - Re-explore the original topic on its own terms.

  G. Generating Analogy

  - Provide an original analogy and explore the similarities and differences.

. Independent Study Plan (from Self-Starter Kit for Independent Study by Doherty and Evans, 1980)

The procedures for independent study provide a comprehensive model for a variety of research topics. At the "process" step, students have the opportunity to refine ideas by redesigning them according to guidelines formulated by Bloom's Taxonomy.

A. Problem Finding

- Interesting questions to know more about

B. Selecting a topic

- Choice for independent study

C. Generating Questions

- Finding out about the topic
- Scheduling time

D. Resources

- Information needed and sources
- Taking notes

E. Processes

- Transforming the information

F. Products

- Ways to demonstrate learning
- Presentation skills

G. Audiences

- Finding and preparing for appropriate audiences

H. Evaluations

- Analyzing results

> *If necessity is the mother of invention -*
> *is curiosity the father?*
> *- Anonymous*

Obstacles to Effective Problem Solving

Questioning skills, critical and creative thinking processes, and problem solving strategies contribute to the intellectual independence of all students. However, like all learners, academically talented students may sometimes demonstrate a resistance to problem solving and independent investigations for a variety of reasons.

Obstacles may be caused by the way students interact with the learning environment. For example, they may not be accustomed to struggling with real problems since they are usually able to solve the textbook variety of problems so easily. Moreover, they may value textbook problems as the only worthwhile type. They may be highly successful in one content area, but fail to transfer comparable strategies to a topic in which they lack basic knowledge or experience. Teachers need to be aware that such students may be poor problem-solvers because they have a deficit in knowledge or strategies.

Difficulty may also arise because of the way academically talented students are perceived by others. Peer pressure to conform or compete may cause anxiety, and the lack of opportunity to work with intellectual peers may create a sense of isolation. These feelings may be compounded by social immaturity or by rapid acceleration to higher grade levels. The unrealistic expectations of parents and teachers, as well as peers, may cause students to become manipulative or to withdraw. They may be victimized by the "fastest gun syndrome" in which they are expected to know every answer and taunted when they fail to do so.

Fear of loneliness or feelings of inadequacy may contribute to a fear of risk taking and to a fear of failure. Sometimes fear of success may prevent students from distinguishing themselves because they perceive responsibility as a burden that accompanies outstanding ability.

The students' attitudes, personalities, and overt behavior may also cause obstacles to affect problem solving. If they are arrogant or have a know-it-all attitude toward learning, they may not be able to accept new ideas or improve existing ones. A tendency to be too judgmental or too convergent may create mind sets that are difficult to break. Intellectual aggression may cause others to view them negatively. Individual learning styles may depend too heavily on a particular mode of sensory input. For example, a strong visual learner may become confused by relying on information acquired through listening. Organization, persistence, patience, perfectionism, and/or independence are characteristics that may have negative or positive influences depending on the degree to which they are expressed.

Summary of Problem Solving Obstacles

I. Extrinsic problems
  A. Content related
    1. Terms/language
    2. Concepts/operations
    3. Format/procedures
    4. Tools/skills
    5. Relationships/implications
    6. Levels of difficulty
  B. Interpersonal
    1. Parental pressure
    2. Peer pressure
    3. Competition
    4. Manipulation
    5. Isolation
    6. Social immaturity
    7. "Fastest gun" syndrome

II. Intrinsic problems
  A. Affective
    1. Fear of taking risks
    2. Feelings of inadequacy
    3. Fear of failure
    4. Fear of success
    5. Loneliness
  B. Attitudinal/Behavioral
    1. Inflexibility
    2. Arrogance (know-it-all)
    3. Withdrawal
    4. Intellectual aggression
    5. Disorganization
    6. Persistence
    7. Patience
    8. Perfectionism
    9. Mind set
    10. Sensory confusion
    11. Independence

Suggestions for Overcoming Obstacles

Creating an accepting atmosphere can help students feel comfortable with the way they are perceived and with the way in which they perceive others. Students with blocks to problem solving may need to develop self-management strategies and to develop value and respect for their abilities and the abilities of others. They may need to learn to accept differences in a positive way and to recognize and accept limitations. Helping such students to set realistic goals will enable them to overcome high expectations created by themselves or by others. Content related difficulties and many attitudinal limitations can be improved by utilizing the strategies throughout this guide. Interpersonal and affective concerns may also be alleviated by providing opportunities for the following experiences:

- Analyzing values
- Listing/prioritizing
- Role playing
- Game simulations
- Role reversals
- Mirroring
- Social simulation
- Dramatization
- Visualization
- Feedback
  - Metacognition
  - Think-Pair-Share
  - Video/Cassette recordings.

Suggestions for Creating a Problem Solving Environment

- Help students develop a positive attitude toward problem solving. Students must have the confidence that the obstacles are within their capability to overcome. They must believe that their thinking and problem solving skills are adequate to attack a problem.
- Develop problems appropriate for different ability levels. Good problems frequently permit different levels of sophistication in their solution.
- Allow students to work together. The discussion of problems, sharing of ideas, debating of alternatives, and verification of solutions are all important skills in problem solving.
- Select problems which provide for maximum student involvement and minimum teacher guidance.
- Use skillful questioning to help students sense what a problem is about, to form a mental picture of the relationships or patterns, and to systematically determine procedures and alternatives.
- Break complicated problems into manageable parts when frustration approaches, but be alert to exercise sufficient restraint that the challenge (and resultant satisfaction) is not also removed.
- Discuss problems, reasonable answers and estimates, alternative procedures for finding solutions, and variations of problem situations.
- Compliment alternative solutions or approaches to problem solving situations. Let students know that you encourage different ways of thinking about problems.
- Be flexible in permitting students to continue with inaccurate or inefficient results or procedures for a time. Avoid being overly didactic or the source of all answers, or an answer verifier. Encourage students to look to their own resources for answer validity.
- Provide a variety of problem solving opportunities. Such situations might include:
    - Problems that have no answer or have more than one answer. Too often students have the impression that all problems have only one exact answer.
    - Problems for which the students must collect or generate some of the information or data. Often textbook problems provide all necessary facts while everyday problem solving experiences require the selection of relevent information.
    - Some instances where the problem is not well-defined and needs clarification.
    - Problems with superfluous or insufficient information.
    - Problems involving logic, reasoning, testing of conjectures, reasonability of information.
    - Open-ended and investigatory problems.
    - Problem situations calling for more than one method of solution.

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APPENDIX

Resource Sheet Listing

Page

1. As Busy As A Bee? 23

2. Elephant Stew 47

3. Excerpt from "Su An" 53

4. McGilliccuddee Mania 59

5. Cinderella 69

6. Distinguishing Between Strong and Weak Arguments . . . 77

7. Matrix Logic 87

8. Stop Taking Us for Fools 93

9. Creative Reading Checklist 113

10. Visual Brainstorming (SCAMPER) 135